THE IMPACT OF USER INTERFACE DESIGN ON IDEA INTEGRATION IN ELECTRONIC BRAINSTORMING: AN ATTENTION-BASED VIEW

BY

ELAHE JAVADI

DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Business Administration
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2011

Urbana, Illinois

Doctoral Committee:

Professor Joseph T. Mahoney, Chair
Associate Professor Judith Gebauer, University of North Carolina-Wilmington
Assistant Professor Wai-Tat Fu
Associate Professor Tiffany B. White
Assistant Professor Ramanath Subramanyam

ABSTRACT

This dissertation introduces and empirically examines an attention-based theory of idea integration that underscores the importance of IS user interface design. The assumption is that presenting ideas via user interface plays a key role in enabling and motivating idea integration in electronic brainstorming (EBS), and thus advances productivity. Building upon Cognitive Network Model of Creativity (CNM) and ability-motivation framework, the attention-based theory proposed and tested in this dissertation focuses on two major attributes of user interface: visibility and prioritization. While visibility enables idea integration via directing attention to a limited set of ideas, prioritization enhances the motivation for idea integration by providing individuals with a relevant and legitimate proxy for value of the shared ideas. The laboratory experiments conducted as part of this dissertation's research showed that although communicative idea integration (e.g. mere reference to partners' ideas) increased when visibility increased, elaborative idea integration increased only when visible ideas where highly diverse. Laboratory experiments also indicated that the influence of prioritization on idea integration takes different forms for communicative idea integration and elaborative idea integration. While the effect of prioritization on communicative idea integration is significant through the mediating effect of perceived value of information, the effect of prioritization on elaborative idea integration is significant through the mediating effect of perceived value of idea integration. To further examine part of the unexpected results of the lab experiments, this dissertation introduces and computationally examines a model of idea integration that formulates the joint influence of (1) idea visibility as an electronic media feature, (2) attention to partners' ideas as a cognitive attribute, and (3) individual's experience with idea integration as a decision-making factor on idea integration in EBS. Results from this dissertation's computational experiments suggest that

the influence of idea visibility cannot be expressed in terms of simple effects of either attention or experience. Rather, the effect of visibility on idea integration is moderated by partners' attention-experience disparities. Full description of the theory and the result of the experimental and computational studies and their implications will be presented in separate chapters. This dissertation's research has implications for both the practice and research of knowledge management, especially for the attention-based view of the organization.

To my parents

and

To my love, Amir

ACKNOWLEDGEMENTS

I have been fortunate to have studied at the University of Illinois. I feel particularly lucky to have Professor Joseph T. Mahoney as my advisor. Ideas and lessons I learned from Professor Mahoney have influenced my mind beyond my PhD dissertation. He truly is an inspiring scholar whose dedication to students' achievement has empowered my progress and those of many others. Despite his involvement in many research, teaching and service activities, he always makes himself available to his students who need help. His meticulous mentoring shows his sincere care for his students. He is a great role model for me as a researcher and educator. I would like to thank Professor Mahoney for his mentorship and his invaluable guidance throughout my doctoral studies.

I am also very grateful to my committee co-chair and advisor Professor Judith Gebauer, who took me under her wings when I started to develop my research. She encouraged me and patiently guided me through every single step of my research process and she never ceased to believe in me. Professor Gebauer's advice has helped me tremendously in my dissertation research and in my academic life.

I also feel lucky to have worked with Professor Wai-Tat Fu. Brainstorming research ideas with Professor Fu helped me shape my research and practice knowledge integration which I aspired to study during my PhD program. His inexhaustible energy and passion for research are indeed unparalleled and inspirational.

My thanks also go to Professor Tiffany B. White, who advised me on critical aspects of my dissertation's research methodology design. I still remember her many insightful comments on the PhD process, which somewhat eased the pain for me when navigating through it. Additionally, special thanks to Professor Ramanath Subramanyam, who led me into the

fascinating research areas within Information Systems. My experience working with Professor Subramanyam taught me a lot about how to conduct academic research, I am very grateful for his help

Over the years I have benefited from valuable advice provided to me by Professor Huseyin Leblebici, Professor Gregory Northcraft, Professor Ali Tafti, and Professor Madhu Viswanathan and I am grateful for that. Their insights have been and will be great sources of inspiration for me for the future. I also want to thank the department staff whose support has been indispensable for me during my PhD process. They are Claudia Gaston, JE Miller, Julie Monroe, and Margo Robins, among many others. I would also like to thank my peers and friends, John Burke, Maheshi Dassanayake, Vida Ferdowsi, John Huang, Sogol Jahanbekam, Chih Liu, Mahka Moeen, Sara Shafaei, and Yuju Tu for their friendship and for their support throughout my PhD program. They were always willing to share their ideas on my research and they did so with open minds and great patience.

Finally, I dedicate this dissertation to my parents and to my husband, Amir. I would not have pursued my PhD without the encouragement and support from them. My family is the ultimate inspiration of my life. It would be unimaginable that I could complete my PhD process without their support.

TABLE OF CONTENTS

CHAPTER 1

THEORETICAL MODEL

1.1.Introduction

Despite the pervasive use of electronic media for group brainstorming, evidence from research and practice suggests that electronic brainstorming systems (EBSs) may have created an illusion of productivity, offering limited benefits in terms of quantity or quality of the ideas generated by individuals during the brainstorming process (Fjermestad & Hiltz 1999, 2001). *Brainstorming* here is defined as generating, sharing, and combining ideas or solutions on a problem or task by more than one individual (Shepherd *et al.* 1996; Reinig *et al.* 2007). An experimental study at Sandia National Laboratories (Davidson *et al*. 2007), for instance, found that individuals working alone outperformed those working in groups in terms of the quantity of ideas generated and the extent of the elaboration on each idea. Similar research studies also examine the EBS productivity illusion in terms of process gains such as cognitive stimulation and synergy, and process losses such as cognitive interference (Pinsonneault *et al.* 1999).

Examples of process gains in electronic brainstorming that have been corroborated in empirical studies are elimination of production blocking, alleviating evaluation apprehension in anonymous EBSs, and tackling social loafing through use of technology for realizing some forms of social comparison (Vreede & Dickson 2000; Fjermestad & Hiltz 2001; Briggs 2006). Shepherd and colleagues (1996), for instance, reported a 63% increase in the number of unique ideas generated during a brainstorming session when a highly salient social comparison mechanism was utilized in the brainstorming.

Some research studies, however, suggest that process losses may outweigh process gains in electronic brainstorming (Pinsonneault *et al.* 1999). An underpinning thesis for losses during electronic brainstorming is associated with attentional processes. Losses that arise from inefficient attentional processes are two-fold: (1) loss may be caused by attention diversion because of excessive exposure to other people's ideas, or (2) loss may be caused by lack of attention to other people's ideas. The quest for finding optimal attention, in which process losses are restrained and EBS productivity is improved, motivates the current dissertation's theory development. We suggest that EBS productivity can be examined through theoretical framings for IS artifact design with respect to managing underpinning attentional processes in brainstorming. Technology-independent IS design features derived from such a theory can inform IS user interface design (Briggs 2006).

The theory developed here underscores the ability of IS user interface (UI) design to advance EBS productivity with an emphasis on idea integration as the desired outcome. The extant IS research literature on idea integration has proven its relevance to and importance for the overall productivity of EBS (Dennis 1996; Vreede *et al.* 2000; Robert *et al.* 2008; Sussman & Siegal 2003). Further, organization science research has shown that the ability of an organization to appropriate the value of knowledge owned and accumulated by individuals depends on its ability to encourage idea integration within groups (Okhuysen & Eisenhardt 2002). Idea integration within groups initiated by heterogeneous, diverse, and specialized individuals is essential for creating knowledge-based capabilities of an organization (Grant 1996b; Kogut & Zander 1992; Santanen *et al.* 2004). EBS is an ideal locus for supporting idea integration since electronic media has become a prevalent platform for communication among individuals within and across organizations.

With few exceptions (e.g., Vreede *et al.* 2000; 2010, see Table 1.1 on page 10), however, the dominant focus in EBS research has been on idea sharing determinants and detriments, with little consideration for the ultimate goal for shared ideas to be integrated and used by others. In the broader literature on brainstorming, for example, when comparing productivity of nominal brainstorming (individuals ideate on a problem separately) with that of verbal brainstorming (brainstorming: individuals ideate on a problem collaboratively in groups), idea integration is not always regarded as an essential measure of brainstorming productivity (Fjermestad & Hiltz 1999, 2001). Similarly, in EBS research literature, when comparing verbal brainstorming to electronic brain-storming, the main foci are idea generation and sharing. Typically, less attention has been given to idea integration and to leveraging IS capabilities; particularly user interface for supporting idea integration. It should also be noted that, in general, antecedents of idea integration differ from but sometimes overlap with those of idea generation and sharing (Vreede *et al.* 2003; Santanen *et al.* 2004).

In contrast, some research regards idea integration as an important primary contributor to productivity gains in groups (Vreede *et al*. 2003). For example, several experimental studies have addressed individual idea integration behavior and measured the extent to which individuals build on the ideas shared by others (Dennis 1996; Robert *et al.* 2008; Vreede *et al.* 2010). Others have examined productivity implications of idea integration for electronic groups (Vreede *et al*. 2000, 2010).

To bridge the identified gap in the research literature, the proposed theory focuses particularly on idea integration for achieving EBS productivity advantages in comparison with verbal and nominal brainstorming (Dennis 1996; Homan *et al.* 2007; Robert *et al*. 2008). For accomplishing EBS productivity superiority through the advancement of idea integration, IS interface features are crucial for channeling individuals' attention and for enabling and motivating idea integration.

The proposed theory builds upon an *attention-based view* of user interface influence on idea integration (Simon 1947; Ocasio 1997). It builds upon the cognitive network model of creativity (Santanen *et al*. 2004) and adopts a *motivation-ability* approach to interface design (Santanen *et al*. 2004; Robert & Dennis 2005; Thoemmes & Conway 2007). For ideas to be integrated they must be exposed to individuals' attention; individuals must create the connections among different ideas, thus they must be able and motivated to do so. Since the IS user interface is the main point of access to the shared ideas for individuals in EBS (Sheppard & Rouff 1994), user interface features play a key role in enhancing individuals' abilities and motivations for idea integration (Dennis *et al.* 2001). This dissertation's theory posits that channeling attention (i.e., directing individuals' attention) through manipulation of visibility of the ideas (i.e., information saliency) (Briggs 1995) and prioritization of ideas (Dennis 1996) influence individuals' idea integration behavior. The developed theory thus accounts for underpinning processes for idea integration and uses the IS artifact as an instrument to cultivate the potentials for idea integration (Briggs 2006). To summarize, the attention-based view of IS user interface design for enhanced idea integration is based on the following premises:

1. Individuals' idea integration behavior in electronic brainstorming depends on the extent and quality of attention allocated to the ideas shared by others (Simon 1947; Ocasio 1997);
2. Attending to the shared ideas lead to retrieval and activation of related concepts which advances potentials for idea integration (Santanen *et al*. 2004); and

3. Since the IS user interface is the main point of access to the shared ideas, attention can be managed by employing user interface features to enable and motivate idea integration (Suedfeld *et al.* 1992; Thoemmes & Conway 2007).

The proposed theory is technology-free in that the effect of the independent constructs (i.e., *visibility* and *prioritization*) on idea integration is explained through the processes that shape idea integration behavior rather than a specific technological implementation of them (Briggs 2006). Although specific IS artifact instances may implement this theory's constructs in different ways, we maintain that the general features of IS artifacts as represented in the constructs are core to realizing the attentional processes that lead to idea integration.

The theory developed here contributes to the IS research literature on EBS and idea creation in at least three ways. First, building upon Simon's (1947) logic for attention as a scarce resource in organizations, this theory links IS interface attributes to the creation of organizational knowledge-based capabilities in an era of collaboration technologies' prevalence (McAfee 2006). Second, building upon the EBS literature, it extends the use of interface attributes for enhancing brainstorming productivity through promoting idea integration (Dennis *et al.* 1996; Vreede *et al.* 2003). Third, it creates the foundation for empirical studies that contribute to technology design and managerial decision making regarding the choice of technologies to improve collaboration and knowledge creation within organizations (Briggs 2006; Zhang & Watts 2008). Examining idea integration in electronic settings using the current dissertation's developed theory can also contribute to the resolution of the paradox of electronic brainstorming productivity by providing new instruments for improving productivity.

The guidelines derived from the theory for electronic brainstorming design will apply to computer-supported-communication (CMC) in any context where knowledge creation is the goal. More specifically, we regard EBSs as instances of CMCs that generally support idea sharing within groups (Fjermestad & Hiltz 2001). In addition to idea sharing, the theory proposes methods for making EBSs in particular and CMCs in general more amenable to idea integration. The propositions derived from the theory are testable in field or laboratory experiments.

Since IS theories are expected to focus on technology-supported processes rather than just the technology (Briggs 2006), we first expand on idea integration process and dynamics. We note the links between knowledge integration and EBS productivity and we proceed to present the attention-based view of idea integration. We then consider the links between IS user interface features and idea integration (Mitchell 2006) and the remainder of the dissertation conceptualizes each of the constructs in the theory.

1.1.1. Idea Integration and Electronic Brainstorming Productivity

The brainstorming process involves the generation, exchange and individual-level processing of ideas, discussing the results of the individual-level processing within the group, leading to the integration of the ideas (Homan *et al*. 2007). Assuming that no one individual has sufficient information to generate the best idea, idea integration becomes a key to realizing more fully the value of the individually generated ideas (Dennis 1996; Vreede, *et al*. 2003; Robert *et al*. 2008). Therefore, idea integration is a key process for enhancing EBS productivity that should be of interest to EBS designers and leaders. Some empirical studies of EBSs have accounted for idea integration in the measurement of group productivity (Vreede 2000; 2010), and have implemented mechanisms such as Relay methods, for improving idea integration. In Relay method, individuals in the group are organized into subgroups and are engaged in the brainstorming process in a sequential form, that is subgroups are instructed to start the ideation process where the previous subgroups ended (Vreede 2000; 2010).

Integration is a critical pattern for knowledge creation by which dimensions of more than one individual's ideas are combined to create new and more integratively complex ideas (Okhuysen & Eisenhardt 2002). Integration is, in fact, the combination of explicit knowledge items (Nonaka 1994; Patanayuki *et al.* 2006), and idea integration occurs when individuals consider some or all dimensions of others' ideas (recognition) and create conceptual connections among different dimensions (integration) (Gruenfeld & Hollingshead 1993). While creating conceptual connections among different ideas requires relatively the same level of creativeness as sole idea generation, attending to others' ideas represents an additional process necessary for achieving idea integration. Likewise, when contrasted to idea sharing, the supplementary requirement for idea integration is individuals' attention to the ideas shared by others (Dennis 1996).

If the generated and shared ideas are not attended to, processed, integrated and used by the recipients, idea sharing will not provide any benefit to the organization's success (Grant 1996b; Zhang & Watts 2008). Extant empirical studies on idea integration have indicated that integration does not occur automatically, individuals must be able and motivated to integrate ideas (Santanen *et al*. 2004; Homan *et al.* 2007). As such the attention-based theory posits that in addition to being concerned with the quantity and quality of ideas generated during the brainstorming process (Dean *et al*. 2006; Reinig *et al.* 2007), researchers, IS designers, group designers, and facilitators should be concerned with the rate and quality of idea integration during the brainstorming process. Since many organizations are adopting online collaborative knowledge creation platforms (McAfee 2006), the theory developed here focuses on computer-mediated or electronic brainstorming. As a result, the IS user interface becomes central to facilitating idea integration and thus to enhancing group brainstorming productivity.

1.1.2. Idea Integration: Definition

Idea integration occurs within groups where ideas are combined by individuals. In IS studies, idea integration or elaboration has been posited as complementary to idea generation. In EBSs for instance, task-relevant contributions are either task-relevant ideas or elaboration on previous ideas. The concept of an idea has been defined as a verb-object combination in prior IS research studies (Vreede *et al*. 2000). Some verb-object combinations, however, may represent ethical statements such as: “I agree with solution A” (Simon 1976). Building upon the prior research, therefore, we define an *idea* as a basic element of thought represent by verb-object combinations and consist of at least one testable proposition (Simon 1976; Vreede *et al*. 2000). A statement is still considered an idea if it is a mixture of ethical statements and testable propositions. For example: “*I think some sort of tarp would be useful for shade and shelter”*, is an idea exchanged during a desert survival brainstorming session. However, if the shared information primarily consists of ethical or imperative statements like *“I prefer solution A”* or *“I believe we should adopt solution B”*, or like the example from the desert survival brainstorming: *“We have to stick together though”,* it is not considered an idea, if it does not contribute substantial content. Similarly, if the shared information is a definition or description of an object, event or a process that does not include individual’s perspective on it and does not provide any indication of relevance to the topic discussed in the group, it is not considered an idea (Baker-Brown *et al.* 1992). An example of such a descriptive statement from the desert survival brainstorming session is: “*Well we are 65 miles off course and we know we are in and S - SW of* *the mining camp".* So, effectively, we exclude two forms of verb-object combination, namely, purely descriptive and ethical statements, from the definition of an idea.

Idea integration, also referred to as combination or synthesis, is considered the most fruitful phase of the creative process (Osborn 1953). The current study maintains that idea integration is a critical process that has dimensions of both convergent and divergent thinking (Guilford 1956). Integration involves divergent thinking in that individuals consider different perspectives of the shared ideas; integration involves convergent thinking in that individuals must create connections among different dimensions of the various ideas to frame an integrated idea.

In the IS literature, idea integration has been conceptualized as the explicit reference to partners' ideas in forms of comments, and has been usually categorized as a measure of communication within the category of effectiveness measures (Fjermestad & Hiltz 1999, 2001). EBS studies have referred to the task-relevant reference to previously generated ideas as elaboration and have included the concept in productivity measurement (Vreede *et al.* 2000, 2010). Moreover, an elaboration coefficient has been suggested to represent the extent to which discussion is taking place during electronic meetings. Other research studies have identified knowledge integration as the outcome of elaboration, which is described by information exchange and information processing at the individual level, followed by integration at the group level (Homan *et al.* 2007, see Table 1.1). Information adoption and use are also two very closely related constructs used in IS research studies because it involves attending and appropriating the task-relevant shared information for performing the task (Dennis 1996; Ferran & Watts 2008; Sussman & Siegal, 2003).

Table 1.1: Studies of Idea- and Knowledge- Integration			
Study	**Dependent Variable**	**Definition of the Construct**	**Approach**
Dennis (1996)	Information use	Use of unique information owned by others	Information recall-exchange- processing and use theory
Vreede *et al*. (2000; 2010)	Elaboration	A task relevant reference to a previously submitted unique idea. So, e.g., a comment	Relay (serial) vs. decathlon (parallel) sub-groups
Okhuysen & Eisenhardt (2002)	Knowledge Integration	Use of unique knowledge pieces owned by others	Use of formal interventions for directing and switching attentions
Sussman & Siegal (2003)	Information adoption	A manifestation of knowledge internalization in organizational advice-receiving context	Adoption and information influence theories
Homan *et al*. (2007)	Information elaboration	Elaboration on task-relevant information and perspectives	Pro-diversity as integration enabler
Robert *et al*. (2008)	Knowledge integration	Making reference to other's ideas	Social capital theory

The current dissertation uses the term idea integration to explicitly emphasize the integration aspect of information adoption and use and to highlight the level of analysis (within groups). We suggest that idea integration is a process that precedes the creation of combinative ideas but does not guarantee the creation of unique ideas. Different levels of idea integration thus contribute to brainstorming productivity in different ways. The basic level of integration, indicated by a statement such as "I agree," for instance, is believed to be important in giving meaning and value to the idea that is being referred to (Vreede, *et al*. 2000; 2010). To distinguish between different levels of idea integration ranging from mere reference to others' ideas to completely integrating others' ideas with those of their own, the current dissertation applies the well-studied concept of *integrative complexity* in social psychology (Baker-Brown *et al.* 1992; Suedfeld *et al.*1992).

1.1.3. Integrative Complexity

Integrative complexity is a measure of the individual tendency to consider decision-relevant information from more than one dimension (Suedfeld *et al.* 1992). Within groups integration involves the generation of new conceptual relations among different perspectives (Gruenfeld & Hollingshead 1993). Integrative complexity has been identified by two phases of differentiation and integration. Differentiation is the perception of different aspects of a subject, and integration is the recognition of connections among those aspects (Suedfeld *et al*. 1992). Idea integration, in the current study, is defined as an activity that leads to creation of integratively-complex ideas. Idea integration occurs when an individual refers to the ideas proposed by other individuals (Vreede *et al.* 2003; Robert *et al*. 2008) and creates the conceptual connection among those ideas and his or her own ideas (Gruenfeld & Hollingshead 1993; Santanen *et al*. 2004). Reference may be made to an idea as a whole or to some *dimensions* of the ideas. Even though *dimensions* are considered building blocks in the study of integrative complexity (Suedfeld *et al.* 1992), we are not aware of previous research studies that have explicitly defined them. An i*dea dimension* is defined here as "a unique testable proposition." Thus, the shared information is called a multi-dimensional idea if it includes more than one unique testable proposition, an example from the desert survival would be *"Some sort of outer shell jacket that is water proof, can be used to collect water if it rains, covers body at night".*

It is important to distinguish between the “state” and the “trait” of integrative complexity. Defining integrative complexity as a cognitive or information processing style (Driver & Streufert 1969; Harvey *et al.* 1961), some researchers refer to it as a trait while many other researchers consider it as having dimensions of both trait and state (Streufert & Swezey, 1986). Some research studies have also referred to integrative complexity as a changeable trait. Trait complexity is the one that is less likely to change while state complexity is prone to environmental mediators (Suedfeld *et al.* 1992).

It is not certain, however, whether higher integrative complexity leads to better quality outcomes in general tasks. However, since brainstorming involves creative thinking, higher integrative complexity is expected to lead to better ideas. Gruenfeld and Hollings-head (1993) have conjectured on the correlation between integrative complexity and task performance based on the task type in which the performance of conceptual tasks and intellective tasks are positively correlated with integrative complexity. Further, integrative complexity and task performance will be much more highly correlated for a non-decomposable task than for a decomposable one. Since the current dissertation is concerned with brainstorming, which is a creative and non-decomposable task (Desanctis & Gallupe 1987), we presume that idea integration will contribute to the quality of the brainstorming outcomes.

In empirical studies of group brainstorming, idea integration has been shown to improve productivity or outcome quality (Okhuysen & Eisenhardt 2002; Patnayakuni *et al*. 2006; Robert *et al.* 2008). In the studies of elaboration in EBSs, for instance, Relay groups in which sub-groups work in a serial manner were found to be more productive than Decathlon groups in which subgroups worked in a parallel manner (Vreede *et al*. 2000; 2010). The productivity gain was mainly associated with higher elaboration rather than with an increase in the number of unique ideas (there was a slight but not statistically significant improvement in the number of unique ideas). The extent of elaboration has been measured with a collaboration coefficient calculated as the number of task-relevant elaborations over the number of task relevant communications minus one (Vreede *et al.* 2000; 2010). Whether or not there is a correlation between elaboration coefficient and the quality of ideas, however, is still an open question.

We define idea integration based on integrative complexity for several reasons. First the definition allows for flexibility in the operationalization of idea integration within groups. With few exceptions (Vreede *et al.* 2000, 2010) empirical studies have focused mainly on the quantity of integration as measured by the number of references made by individuals to ideas of others (Homan *et al*. 2007; Robert *et al.* 2008). However, since different combinations of the same factual information (testable propositions) may generate different combinative outcomes (Okhuysen & Eisenhardt 2002), measuring levels and quality of idea integration is important in examining the value created by idea integration (Vreede, *et al*. 2000). The level of idea integration within groups also influences the value of knowledge integration at the organizational level. The current dissertation's differentiation among integration levels or degrees enables stronger theory development and more precise empirical testing, which can better link idea integration within groups to the creation of organizational knowledge-based capabilities (Santanen *et al.* 2004). Based on this definition of idea integration, the next section proceeds to describe the proposed attention-based theory.

1.2.Background

The proposed attention-based view here is based on Simon's logic of attention being a scarce resource (Simon 1947; March & Simon, 1958). The assumption is that attention is one essential element for initiating idea integration in groups and that in electronic groups IS user interface may be used to manage the underpinning attentional processes of idea integration. Like previous research studies of attention scarcity in organizations, the desired process here for individuals is to integrate ideas within groups. The desired action or process, in attention based view of the firm, for instance, is referred to as a *move* (Ocasio 1997). A *move* is defined as an intentional processes shaped by individuals. Desired moves can be nurtured through regulating forces that channel individuals' attention towards them. Regulating forces for channeling individuals' attention can be implemented through organizational rules that value and motivate the desired moves. Similarly, idea integration, as the desired move in the study, must be valued and be motivated; and the proposed theory suggests that valuing and motivating idea integration can be realized by use of IT interface features for managing integration's underpinning attentional processes.

The attention-based theory developed in this dissertation is also based on the cognitive network model (CNM) of creativity and ability-motivation framework (Santanen *et al.* 2004; Thoemmes & Conway 2007). CNM has been viewed as a foundation for under-standing causality in creativity contexts. We regard idea integration as a specific form of creativity that relies on perceiving different dimensions of the shared ideas, retrieving relevant concepts from long term memory and creating novel combinations among perceived and activated concepts (Santanen *et al*. 2004). Further, for idea integration to occur individuals must be *able* and *motivated* to do so (Vreede *et al*. 2003). In the following sections, the developed theory is positioned with respect to the cognitive network model of creativity and ability-motivation framework.

1.2.1. Cognitive Network Model of Creativity

The Cognitive Network Model (CNM) of creativity explains causality in creativity based on principles of long term memory retrieval and activation in working memory. Models of memory suggest that for information to become available to the working memory it should be retrieved and activated by probing long term memory with cues. For instance, according to the two theories of Adaptive Control of Thought (ACT) and Search of Associative Memory (SAM) (Anderson 1983, 2005; Anderson & Lebiere 1998, Raaij-makers & Shiffrin 1981), memory traces become more or less active as a function of cues in the context. Since CNM has developed a causal relationship among the extent, frequency and diversity of the cues presented to individuals and outcomes' creativity level, it has been used widely a basis for designing collaboration processes with predictable effects (Kolfschoten *et al.* 2010). Similar research studies also use CNM to design effective facilitation mechanisms that warrant more creative group outcomes (Santanen *et al*. 2004).

CNM thus posits that creativity initiates when individuals search in long-term memory's knowledge maps using cues available to them or made available to them through external stimuli. Relevant frames are then transferred from long term memory to working memory and creativity happens when links among originally distant frames are created (Briggs 2006; Santanen *et al*. 2004).

In additional to automatic aspects of search, retrieval, and activation, idea integration requires individuals' mindfulness (Driver & Streufert 1969; Levinthal & Rerup 2006; Santanen, *et al.* 2004). Mindfulness empowers associative thinking (Osborn 1953; Potter & Balthazard 2004) by enhancing recognition of different dimensions of the shared ideas. Recognition of different dimensions invokes search in one's memory using clues contained in those ideas and retrieval of related concepts. Mindfulness also empowers integration by facilitating creating connections among the retrieved concepts (Gruenfeld & Hollingshead 1993).

Thus, when certain ideas are presented to individuals and are attended to, memory traces of related concepts become more active and therefore the connections among those ideas are more likely to be discovered. This happens because in associative memory the frames that are initially retrieved and activated instigate what is activated next through spreading activation (Santanen *et al.* 2004; Anderson 2005). To the extent that the environment enctheages complex behavior and motivates idea integration, it then becomes likely that those connections are articulated as combinative ideas by individuals in a brainstorming process.

Since each idea that an individual attends to provides a potential set of cues that can be used for the individual's memory search process (Potter & Balthazard 2004), the number of potential cues and as a result the level of activation increases as the number of visible ideas increases. However, similar to what happens in many Web 2.0 knowledge-sharing applications (e.g., *Yahoo Answers* and *Mail.ru*) an abundance of information can also divert an individual's scarce resource of attention and overwhelm individual's cognitive resources (March & Simon 1958; Potter & Balthazard 2004; Santanen *et al.* 2004). One method for overcoming the attention diversion is to use the IS user interface to optimally manage individuals' attention.

1.2.2. Individual's Ability and Motivation

Idea integration as an outcome of integrative complexity occurs when individuals are able and motivated to combine ideas with those others. Idea integration relates to the extant constructs of elaboration and integrative complexity (Gruenfeld & Hollingshead 1993; Vreede *et al*. 2000). Complex thinking is not only a matter of ability, but also a matter of motivation (Thoemmes &

Conway 2007). Complexity research proposes that the organizational context can foster different levels of complexity. Situational conditions such as environments rewarding complexity are thought to influence the level of state complexity (Homan *et al*. 2007; Suedfeld *et al.*1992). State complexity is a changeable aspect of integrative complexity and most of the previous literature on integrative complexity research has dealt with state complexity (Gruenfeld & Hollingshead 1993). Therefore, integrative complexity, as a malleable individual information processing style can be enhanced via IS user interface (Suedfeld *et al.* 1992).

Integrative complexity consists of the two phases of differentiation and integration. Differentiation, which is the perception of different dimensions of the shared idea, requires processing of the information contained in those ideas. For processing information contained in the shared ideas, individuals may take two different routes (Dennis 1996): (1) central route is when individuals actively assess the information contained in the ideas they are exposed to; and (2) peripheral route is when individuals' assessment of the information contained in the ideas they are exposed to is mainly influenced by the preferences of others. When individuals take central route thus their ability for perceiving and integrating different dimensions may be facilitated by effective presentation of ideas via the user interface. When individuals take peripheral route, individuals' information processing may be fostered by effective presentation of preferences of others via the user interface. Preference of others, for instance, may be used to prioritize ideas that are displayed the screen. When individuals take peripheral route, therefore, prioritization influences an individual's evaluation of the shared ideas and thus their tendency to use those ideas in integration.

To foster the integration of perceived different dimensions IS interface can foster individuals' disposition towards and motivation for integrating the differentiated dimensions.

Motivation is indispensable for integration. Individuals should perceive value in integration so they become motivated in taking the necessary steps for idea integration. In general, idea contribution in electronic brainstorming occurs when individuals are motivated to generate and share ideas, review the ideas shared by others, generate follow-up ideas and evaluate ideas shared by others (Wasko & Faraj 2005). Idea integration occurs when individuals review and process ideas shared by others and refer to them and use them when creating new ideas (Dennis 1996; Vreede *et al*. 2003; Robert *et al.* 2008). Substantial research literature on idea sharing and the extant empirical studies on idea integration provide suggestions on how to motivate information sharing or integration in the groups. Some research studies (e.g., Vreede *et al.* 2000; 2010) used Relay mode to promote idea elaboration. In Relay mode subgroups follow the brainstorming when previous subgroups finished it. Homan *et al*. (2007), in the lab experiments, promoted pro-diversity beliefs to persuade more information elaboration, which they suggest leads to information integration.

We are unaware of previous research studies that have explored the potential of user interface features to augment state complexity and advance complex thinking but previous research has used display variations when implementing different forms of social comparison (Shepherd *et al.* 1996). To augment state complexity motivation for attending to the shared ideas, any signal of usefulness, legitimacy or relevance of the ideas could be effective (Sussman & Siegal 2003). And since the amount of attention allocated to ideas of others is consistent with the cognitive effort allocated to finding associations among them, higher levels of attention are expected to lead to actuating more idea integration (Simon 1947).The theory focuses on state complexity (Suedfeld *et al.* 1992) and examines features of the user interface that influence an individual’s ability and motivation for state integrative complexity through managing underlying attentional processes.

1.3.Attention-Based View of User Interface Effect on Idea Integration

The crux of the attention-based view is that attending to others’ ideas is essential for idea integration and that attention can be managed through user interface. Building on the cognitive network model of creativity and the ability-motivation framework, the current attention-based theory utilizes *visibility* and *prioritization* of ideas as two key mechanisms by which attention to ideas is directed and reinforced. Prior empirical studies of idea integration use interventions for directing and switching individuals’ attention to enhance elaboration and idea integration (Okhuysen & Eisenhardt 2002; Vreede *et al*. 2000). To advance ability and motivation for idea integration, the proposed theory uses visibility and prioritization as two interface-based interventions for channeling brainstormers’ attentions (Figure 1.1). Since individuals have been shown to be able to focus only on a limited number of ideas at any given time (Simon 1947), we suggest that only a portion of a larger idea pool will receive effective attention. Therefore ideas generated and sharing during brainstorming compete with each other to receive the brainstormer’s attention (Hansen & Haas 2001).

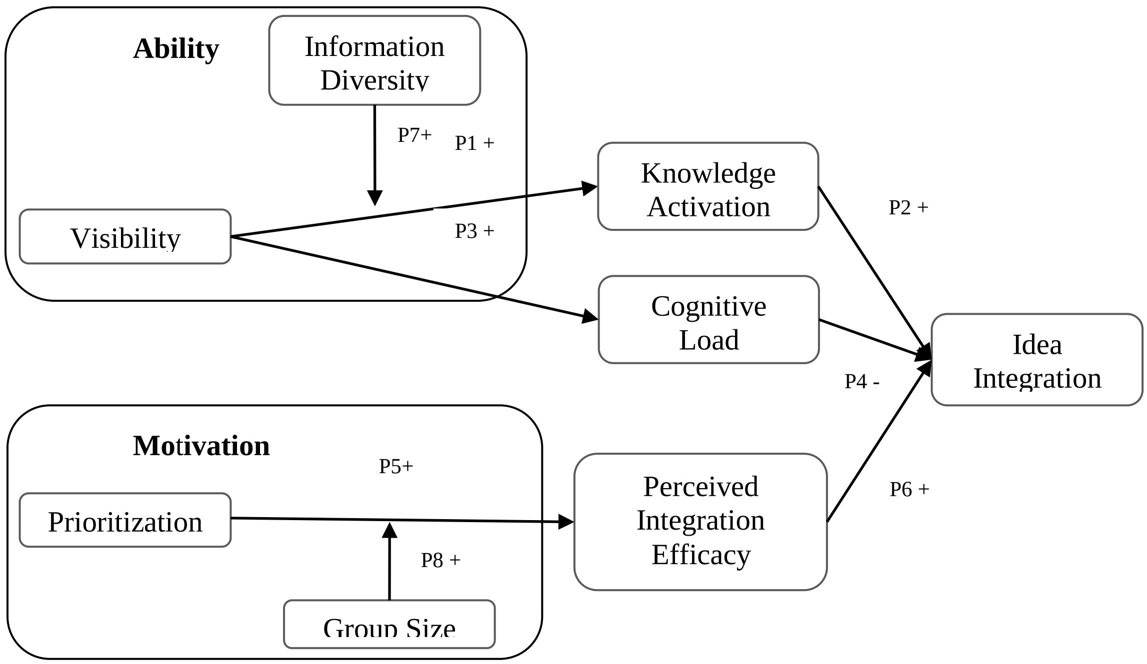


Figure 1.1: Theoretical Framework

For distributing attention among the ideas, chronological order, or rank-based order (order based on collective evaluation of the ideas by the group) are two commonly used methods to organize idea pool on the screen. The definition of idea visibility is consistent with that of availability and saliency of issues and answers in the existing attention-based view research studies (Simon 1947; Ocasio 1997). Prioritization is also a manifestation of selectiveness by which preferences of individuals are represented through the rating of ideas. Prioritization is proposed to stimulate more idea integration when it is the desirable action. Since individuals are selective in the ideas they attend to and since the actions individuals perform --- generation, sharing and integration of ideas --- depends on how their attention is channeled, the current attention-based theory posits that visibility and prioritization are key drivers of the integrative behavior in EBS (Hollingshead 1996; Ocasio 1997).

Since managing attentional processes is the core of the proposed theory, the theory partly addresses the problem of process losses in brainstorming such as cognitive dispersion (Pinnsoneault *et al.* 1999). Process losses have been shown to be as much likely to happen in EBS as they are in verbal brainstorming (Fjermestad & Hiltz 2001). The next section provides the propositions derived from the theory development.

1.4.Propositions of the Attention-based View of Idea Integration and User Interface Design

The proposed attention-based view of idea integration posits that individuals must attend to the ideas shared by others so as to discover new perspectives. Based on cognitive network model of creativity, attention enables creating connections among different dimensions, which is realized through creating associations among their correspondent frames in the working memory (Osborn 1953; Santanen *et al*. 2004). Taking the ability-motivation framework perspective, for directing individuals' attention in a group context and thus enhancing their ability for idea integration, relative visibility or salience of ideas becomes important (Dennis 1996; Santanen *et al*. 2004). In general, saliency of any chosen mechanism is important for attracting brainstormers' attention and thus for its effectiveness (Shalley & Oldham 1997; Shepherd *et al*. 1996). An empirical study of EBS, for example, used facilitation to increase saliency of the social comparison technique so as to hamper social loafing (Shepherd *et al*. 1996). As a result, highly salient social comparison technique lead to a 63% productivity gain compared to only a 22% gain for low salience social comparison.

Based on CNM, however, an excessive number of stimuli presented to individuals caused by high saliency or over-exposure to ideas of others may impede creativity. Thus idea integration, as a creative process, can be enhanced by selective attention to a limited number of ideas at each time. For directing individuals' selective attention, criteria are required for organizing ideas on the screen. If the criteria are a proxy of idea usefulness, then the motivation for idea integration is also enhanced (Thoemmes & Conway 2007). Indeed, any mechanism for inferring usefulness of the shared ideas will augment individual tendency for using them and thus augments motivation (Sussman & Siegal, 2003). Visibility and prioritization are explained in following sub-sections.

1.4.1. Visibility

Visibility of ideas in the theory can be viewed as an interface-based instance of the construct *stimuli quantity per time unit* in the cognitive network model of creativity (Santanen *et al.* 2004). Visibility defines the extent of information that is presented on the screen at any given time. Visibility of the ideas through the user interface facilitates members' exposure to the different dimensions of the shared ideas and thus stimulates activation of associated frames in working memory. According to CNM (Santanen *et al*. 2004), visibility of ideas stimulates search for and retrieval of relevant concepts and thus enables creating connections among those related concepts. Idea visibility is therefore, a predictor of the idea being used in an integration activity when brainstorming is taking place. With the shift from information scarcity to information richness in modern organizations, visibility of ideas becomes even more important (Hansen & Haas 2001). Visibility identifies the extent to which ideas generated by members of the group are salient to other members.

While the visibility construct, in the current dissertation, is examined in the context of IS user interface design, it is independent of any particular type of information system technology (Briggs 2006). Visibility is defined by the portion of the idea pool that is visible on the screen at any given time without extra effort (e.g., clicking) and it is posited that visibility plunges as the effort for viewing the ideas increases. Visibility refers to the number of ideas that are placed on the screen and are visible without requiring any extra effort. By visibility, individuals' attention is channeled through the user interface where ideas are presented to them and the extent to which the ideas are exposed to the viewers depends on their position on the screen. We suggest that visibility of the idea affects the focus of attention, which in turn influences the extent to which relevant concepts are activated in working memory. This activation in working memory based on the stimuli available in visible or salient ideas is discussed next.

According to the cognitive network model of creativity, the influence of visibility on idea integration is described by the mediating effect of retrieving relevant concepts from long-term memory and activation of those concepts in associative memory. Knowledge activation is the outcome of search in long term memory which makes idea integration possible. Increased visibility leads to an increased number of cues made available by visible ideas which facilitates enhanced knowledge activation in memory (Grownski & Bodenhausen 2005). Activation of more items in memory increases the possibility of individuals' discovering and articulating connections among different ideas' dimensions. As pieces of information in visible ideas are more likely to be used as cues to probe an individual's memory, the memory search process is likely to return results that are connected to these ideas; and therefore the visible ideas are more likely to be referred to in the integration process. As such, the current dissertation posits that the overall visibility of the items influence the level of activation of the relevant concepts and thus idea integration:

Proposition 1*: Knowledge activation is positively associated with idea visibility.*
Proposition 2*: Idea integration is positively associated with knowledge activation.*

We maintain that because of the highly asymmetric nature of the knowledge repositories of individuals, exposure to other individuals' ideas is beneficial. It is important to note that even attending to *ad-hoc* categories and cues provided by others' ideas is beneficial when a problem at hand is unstructured and requires diverse information, which is presumed to be the case in brainstorming. The analysis presented here is based on assumptions that individuals possess heterogeneous knowledge on the subject being discussed and that the subject is beyond any single individual's capability for solving it (Vreede *et al.* 2003), and therefore integration of individuals' ideas is desirable. CNM, however, posits that high levels of stimuli presented to individuals also causes cognitive load (Santanen *et al.* 2004). Similar experimental research studies also found that attending to input from others is detrimental to productivity in brainstorming (Potter & Balthazard 2004).

When visibility increases, for example, cognitive overload and interference has been shown to diminish individuals' abilities for discovering associations among activated items and thus their ability for idea integration (Potter & Balthazard 2004; Santanen *et al.* 2004; van Merrienboer & Sweller 2005). Also since the processed ideas and their relevant activated items reside in an intermediate short-term memory that has limited capacity (i.e., memory span), only a few items can be active in memory at the same time. Memory span is defined by the number of elements that one can immediately repeat back; and the general view is that memory has room for about seven elements (Anderson 2005) thus knowledge activation above some threshold may not be possible and thus generate no benefit in terms of idea integration. Particularly, CNM have noted the external stimuli contribute to the idea generation performance only when delivered at a rate that does not overwhelm the brainstormers' attention and cognitive ability (Santanen *et al.*

2004). Considering limited memory span and cognitive interference, the theory proposed here posits that:

> ***Proposition 3****: Cognitive load is positively associated with idea visibility.*
> ***Proposition 4:*** *Idea integration is negatively associated with cognitive load.*

Propositions 1 and 4 imply that idea integration is curvilinearly associated with visibility through the mediating effect of knowledge activation and cognitive load. The curvilinear nature of this relationship captures cognitive load caused by excessive exposure to inputs from others because reading, understanding, and following the inputs of others will cause cognitive dispersion (Pinsonneault *et al.* 1999; Potter & Balthazard 2004). 2004). The curvilinearity rises from the tradeoff between exposure to ideas of others and attending to those ideas and focusing and reflecting on the own background knowledge maps and on creating connections among activated frames (Santanen *et al*. 2004).

Thus, exposure to ideas of others can at times be beneficial and at times detrimental depending on its extent (Potter & Balthazard 2004). While for low levels of visibility, the capacity of individuals for retrieving frames from a cognitive map and for creating a connection, is not fully utilized, high levels of visibility will cause issues with the capacity limits of working memory which is the locus for manipulating activated concepts and for discovering new combinations (Santanen *et al*. 2004). Therefore the theory posits:

This curvilinear effect is consistent with the fact that excessive mindfulness will incur costs in terms of the scarce resource of attention (Levinthal & Rerup, 2006). If high proportion of ideas becomes visible to the group, they may overwhelm brainstormers, and cause distraction or production blocking as well (Briggs 2006; Vreede *et al.* 2000). This tension between combinative creativity (combining already existing ideas) and original creativity (creating new ideas) motivates the current dissertation's quest for finding an optimal or moderate range of exposure to ideas of others. The next section elaborates on prioritization for motivating idea integration.

1.4.2. Prioritization

The cognitive network model of creativity posits that spreading activation as described in the previous section has automatic and conscious components (Santanen *et al.* 2004). The automatic part occurs without intention and the other requires intention and conscious processing. While visibility in the model has bearings on exposure as an instrument for directing the unconscious part of activation, prioritization appertains to the conscious aspect of spreading activation.

In addition to attending to the shared ideas, the conscious aspect of idea integration requires valuing the shared ideas and valuing idea integration. Idea integration in MacGrath's (1984) typology of tasks may be categorized as an intellectual and a cooperative task. For idea integration to occur, it is necessary that individuals in the groups positively evaluate the ideas shared by others (Borgatti & Cross 2003; Sussman & Siegal 2003). Since individuals engage in social interaction based on the expectation of some type of rewards, individuals should perceive value in idea integration so that they process shared ideas and then engage in integrating them with their own ideas (Blau 1964; Siemsen *et al*. 2007).

Prioritization in the current dissertation is defined by using a criterion or a set of criteria for ordering ideas on the screen. The most commonly used prioritization method in verbal brainstorming is collective evaluation by the group. Prioritization based on the collective evaluation of the group is one of the few feasible real-time methods of prioritization in EBS because during brainstorming accurate evaluation of the ideas based on organizational goals (Litchfield 2008) cannot be accomplished. When there is no prioritization, ideas may be displayed on the screen based on their chronological order or ideas may be shuffled on the screen randomly.

The criterion for prioritization, therefore, can be individuals' preferences regarding the shared ideas as indicated through a rating scale. Using this method, ideas are prioritized if they are ordered based on the collective ratings by the group. Prioritization based on collective rating is analogous to the use of citation numbers in academic research dissertation databases to infer the influence of research dissertations. Many state of the art online discussion platforms use similar mechanisms, such as star rating systems (used in *Amazon.com* reviews or in *Yahoo Answers*). Similarly, file, music, and video sharing and many online news dissertations and news aggregators provide individuals with a mechanism to evaluate items and then use the aggregated ratings as a criterion to determine visibility of the items. In EBS, when the number of visible ideas on the screen is limited, lower-ranked ideas will be placed down the list. As a result, the probability of an idea being exposed to individuals' attention is high for high-priority and low low-priority ideas.

To capture an individual's evaluation of others' ideas and an individual's proclivity to idea integration, taking ability-motivation framework, this dissertation introduces the *perceived integration efficacy* construct. Perceived integration efficacy is defined to encompass (1) individuals' evaluation of others' ideas (perceived value of information); and (2) perception of the gains from idea integration (perceived value of integration). We posit that the criterion for ordering ideas influences an individual's perceived integration efficacy. For instance, if the ideas are prioritized based on the group's collective evaluation, individuals attribute more value to the ideas being displayed. Moreover, prioritization reduces uncertainty in individual decision making for idea integration. It is thus submitted that individual perception of the integration efficacy is higher when ideas are prioritized by the group, and this logic leads to the following proposition:

> ***Proposition 5:*** *Prioritization leads to the formation of higher perceived integration efficacy.*

In summary based on the ability-motivation framework, *Proposition 5,* states that prioritization of ideas on the screen will lead to individual's easy access to the preference of others and consequently influences their motivation for idea integration, which is represented through perceived integration efficacy in the theory.

Prioritization provides a signal that may or may not be sufficiently close to the actual value of the ideas. The discussion of how accurately a particular prioritization method represents the ideas' true values or whether prioritization criteria are moderately or significantly discounted by individuals selecting ideas for integration is beyond the scope of the current dissertation. The theory constructed here is based on the ability-motivation framework, which posits that the presence of a prioritization mechanism will enhance the total amount of attention allocated to the shared ideas and boost the extent to which they are reviewed and considered.

1.4.3. Perceived Integration Efficacy

Since individuals differ in the extent to which they value diversity, prioritization provides a feasible (even though imperfect) mechanism for promoting individual's tendency to integrate by boosting their perceived integration efficacy (Petty & Cacioppo 1986). In the theory, perceived integration efficacy is defined by two sub-constructs. The first sub-construct relates to the belief of an individual regarding the value of the shared ideas (*perceived value of ideas*), which is similar to *information usefulness* (Sussman & Siegal 2003) but is more general than *perceived information credibility* (Dennis 1996), which have been used in prior research studies of information adoption and use. The second sub-construct relates to the *perceived value of idea integration*, i.e., an individual's belief regarding the extent to which integration contributes to the value of the ideas generated by the individual, which is a new concept introduced in this dissertation.

According to ability-motivation framework, we posit that, higher levels of *perceived value of idea integration* will elicit more idea integration, because individuals' actions are generally based upon their beliefs of the consequences of those actions (Simon 1976). *Perceived value of ideas*, also, has been proven to augment idea use. For instance, the extant literature on information adoption and use suggests that perceived usefulness or credibility or value of the knowledge item will trigger its use and adoption (Sussman & Siegal, 2003). The current dissertation, thus, posits that individuals are more likely to integrate ideas when perceived integration efficacy is high:

> ***Proposition 6****: Idea integration is positively associated with perceived integration efficacy.*

Perceived integrative efficacy is a composite construct that includes perceived value of ideas and perceived value of idea integration as formative sub-constructs (Edwards & Bagozzi, 2000).. Each sub-construct may be represented by a set of reflective items. The next section considers two important moderators of the current dissertation's framework.

1.4.4. Moderators

The substantial literature on brainstorming and electronic brainstorming has identified a variety of factors that influence the quality of the brainstorming process. Some examples are group nominal and logical size, group composition, group leadership, members' engagement, facilitation and facilitation saliency, time structuring and evaluation mechanisms (Valacich et al. 1995; Fjermestad & Hiltz 2001; Vreede et al. 2003; Santanen et al. 2004;; Zhou & Shalley, 2007). It is naturally expected that the relation-ship between IS user interface and idea integration will be impacted by some of these elements. CNM, for instance, posits that diversity of stimuli presented to individuals increases the associative distance among the activated frames in the working memory and thus augments creativity. Since diversity of stimuli presented to individuals in EBS is represented by the extent of information diversity of visible ideas, information diversity is proposed to be a key moderator in the model. Also, group size which has proven to be a critical moderator in the study of group brainstorming (Gallupe et al. 1992, Dennis & Wixom 2001) is proposed to influence prioritization effectiveness. The moderating effect of information diversity and group size on the association between idea integration and prioritization respectively, is described in the following sub-sections.

1.4.5. Information diversity

As ideas that are attended to become more diverse, the potential for integration increases because information diversity will by itself stimulate integration (van Knippenberg *et al*. 2004). Information diversity here represents variety of the ideas or more precisely the variety of information contained in the ideas generated and shared by individuals within the group. This type of diversity has been linked to higher levels of creativity and cognitive complexity (Harrison & Klein 2007). Information diversity results in diversity of stimuli which draws higher levels of disparity among the concepts that are retrieved from long term memory (Santanen *et al*. 2004). The higher the disparity among activated concepts in working memory, the higher is the potential for knowledge integration. If knowledge that is possessed and shared by individuals is homogenous or identical, there will be no gain from integration (Grant 1996a). Since integration occurs when different perspectives are combined, *ceteris paribus*, a highly diverse set of visible ideas is more likely to stimulate generation of integrative ideas than a less diverse set of visible ideas. A diverse set of visible ideas contains a diverse set of cues, which may be used for probing memory and thus facilitates retrieval and activation of associatively distant concepts (Santanen *et al*. 2004). Diversity of ideas, therefore, increases the extent to which visibility influences knowledge activation and idea integration. Thus, the gains from controlled visibility should increase with higher diversity of the idea pool. As such, the current dissertation suggests that diversity moderates the relationship between visibility and knowledge activation:

> ***Proposition 7****: Information diversity moderates the relationship between visibility and knowledge activation, such that higher levels of information diversity are associated with stronger associations between visibility and knowledge activation.*

While visibility helps with directing individuals' attention, and facilitates activation of the relevant concepts, information diversity boosts the disparity among the activated concepts. Moreover diverse information stimulates original ideas through expanding a group's logical size (Valacich *et al*. 1995). It is important to note that empirical research studies have found that the mere presence of diverse information may not provide any benefits for generation, sharing or integration of ideas (Philips *et al*. 2004; Wooley *et al.* 2008), but individuals must be motivated to do so. To address the motivation issue, the proposed theory includes both visibility as an enabling force and prioritization as a motivational force for enhancing idea integration.

1.4.6. Group Size

Similar to many theoretical and empirical research studies of electronic brainstorming (Dennis & Valacich 1999; Dennis & Wixom 2001), group size is considered to be an important moderator of the relationships proposed in the current dissertation. Particularly, the size of the group is posited to moderate the association between prioritization and perceived integration efficacy. Prioritization here is defined as a mechanism for signaling value or usefulness of ideas (Sussman & Siegal 2003) which is a method for ordering ideas on the screen as well. In larger groups, for example, more people are available for evaluating an idea (Gallupe *et al*. 1992) therefore prioritization based on the collective evaluation of the idea will be more credible in larger groups than it is in smaller groups. Assuming that individuals take the peripheral route for information processing (Petty & Cacioppo 1986) the extent to which the preferences of others is discounted is expect to be less when the group is larger. Thus, there will be more gain in terms of the perceived integration efficacy. Moreover, since in general the idea pool is expected to be larger for larger groups, prioritization has more of an intense effect on ordering ideas in larger groups (wider range of positions on the list of ideas) and has less of an effect in smaller groups. As such, group size is an important moderator in the model:

> ***Proposition 8:*** *Group size moderates the relationship between prioritization and perceived integration efficacy such that prioritization is associated more strongly with perceived integration efficacy in larger groups than in smaller groups.*

Now that the discussion of the proposed theory's constructs and moderators has concluded, a brief guideline for conducting empirical examination of this theory follows.

1.5.Experimental Examinations of the Theory

The proposed theory could be examined in both laboratory and field settings. In laboratory experiments, for instance, hypotheses derived from the propositions of the theory may be tested in an experiment with factorial design: three (Visibility low, medium, and high) by two (prioritization, no prioritization) by two (small groups, large group). Participants in the lab experiments would be invited to brainstorm electronically within groups using an experimental software system that allows for manipulations of visibility and prioritization. The task can be an open idea generation task.

Visibility could be manipulated by varying the number of ideas that are displayed on the screen, and prioritization could be implemented as star ratings provided by the brainstormers. To motivate active participation of the brainstormers during the experiment, each participant could be assigned a score which increases for activities that contribute to the group discussion, including posting an idea, rating other participants' ideas and referring to other participants' ideas. The individual scores then could be used to determine participants' chances for winning a prize.

The software would generate experimental transcripts to be used for measuring idea integration and information diversity. External coders blind to the experimental conditions should be recruited and trained to analyze the transcripts of the experimental sessions, coding each statement and as idea generation or integration (Vreede *et al.* 2000; Baker-Brown *et al*. 1992). Idea generation measurement could be based on the vast IS literature (e.g., Reining *et al.* 2007). Idea integration measurement could be based on elaboration measure (Vreede *et al.* 2000), we anticipate that a multi-level measure of idea integration based on elaboration and integrative complexity measures would best suit the context of the proposed theory (Baker-Brown et al. 1992; Vreede *et al.* 2000).

Perceived integration efficacy should be measured by its two sub-constructs: (1) Perceived Value of Information and (2) Perceived Value of Idea Integration. Each sub-construct may be represented by a set of reflective items asked in self-report questionnaires. Perceived Value of Information, for instance, may be measured by items such as *I am not sure that all the ideas that others contributed had much value or I am convinced that all the ideas everyone posted was valuable* (Dennis 1996). Perceived Value of Idea Integration may be measured using items such as: *Combining my ideas with ideas posted by others created better ideas* or *I am not sure if using ideas posted by others has helped me generate better ideas*.

The theoretical construct of prioritization is expected to have distinct effects when examined in groups of small and large, with group variable being a categorical variable (Fjermestad & Hiltz 1999). Research literature has posited that dyads behave differently from large groups in many ways. In GSS experimental studies the smallest group has usually been groups of three.

Examination of the theory developed here may also be performed by collecting data from relevant resources available online (e.g., across different platforms such as *Yahoo answers*, *Facebook* discussion forums, twitter or similar applications. Empirical research may further examine whether manipulations derived from propositions of the proposed theory elicit different forms of effect when used sequential or parallel settings (Vreede 2000; 2010; Fjermestad & Hiltz, 2001). Empirical studies may also aspire to test the propositions in settings where individuals use the system in several sessions in order to test for possible effects of adaptive structuration on user interface-idea integration relationship (e.g., Niederman *et al.* 2008).

1.6.Contributions

This section summarizes contributions of the current dissertation to four areas of scholarship:

(1) *Contributions to the electronic brainstorming literature*: the conceptualized link between user interface and idea integration which is built based on cognitive network model of creativity (Santanen *et al*. 2004) provides the foundation for design of EBS with predictable levels of idea integration. Idea integration can lead to an increase in the number of combinative ideas and consequently to increased depth in the discussion. Idea integration can thus deepen the understanding within groups and curtail the number of redundant ideas (Vreede *et al*. 2000; 2010). Too much idea integration, however, can limit the original creativity because of cognitive bias. Also, excessive elaboration may limit the boundary of the solution space, when individuals are biased towards certain directions of the solution space based on what they're exposed to and influenced by (Vreede *et al*. 2000; 2010). The theory of idea integration provides a basis for balancing original idea generation with idea integration. It also aspires to contribute to the discussion of productivity and effectiveness of EBS (Vreede *et al*. 2003; 2010) by advancing idea integration as a key EBS productivity measure (Dennis & Valacich 1999).

(2) *Contributions to the IS literature on user interface design*: this study extends the use of interface attributes for achieving idea integration and constructs a theory that links IS user interface design to the underpinning of attentional processes for enabling and motivating idea integration (Dennis *et al*. 1996). The quest for finding a better fit between user interface features and the cognitive requirements of the idea integration provides a new pathway for research and practice on IS interface design. IS interface research has high potentials for supporting

cognitively intensive tasks such as electronic brainstorming and the constructs here can inform user interface design to support it (Rao *et al*. 1992).

(3) *Implications for organizational knowledge integration and use*: building upon Simon's (1947) logic for attention as a scarce resource in organizations, the proposed theory links IS interface attributes to the creation of an organization's knowledge-based capabilities. Idea integration and elaboration (Vreede *et al*. 2003) are important for ensuring the relevance of EBS to the creation of an organization's knowledge-based capabilities. This theory thus reinforces the role of IT for the creation of organizational knowledge resources. The proposed role of IT for the creation of organization knowledge capabilities can rationalize IT investments in organizations and provide a basis for user interface customization efforts.

(4) *Implications for practice*: With the extensive use of collective content creation platforms within organizations, we provide a set of decision making criteria for managers and group leaders to optimally employ the resources of their knowledge workers. For instance, managers are usually faced with the trade-off between breadth and depth of the ideas that are generated in the groups when exposing individuals to their partners' ideas (Vreede *et al*. 2000). While elaboration and idea integration ensure depth in the discussion, it is desirable that the breadth is also preserved. Insights from the proposed theory can inform technology choices to achieve the desired level of depth or breadth. Furthermore, empirical studies based on the theory proposed here and its extension may prove to be insightful to managerial decision making on the choice of technological tools for enhanced idea integration performance.

1.7.Future Research

Although idea generation and sharing provide no benefits to the group and organization unless ideas are integrated, and used (Grant 1996b), the first two are necessary for idea integration within groups. Therefore, the focus of the current theory on idea integration reflects the boundary conditions of the proposed theory. Eventually, a more comprehensive theory of user interface design that addresses all three processes –generation, sharing, and integration – should be developed.

It is also desirable to examine whether the method of prioritization matters. IS researchers, for instance, have found that having a basis for social comparison improves productivity but the baseline level does not affect the results (Shepherd *et al*. 1996). A similar question exists for levels and methods of prioritization to discover whether the form of prioritization methods induces a significant change in its effect on idea integration.

Also since information diversity as a key enabler of idea integration is a convoluted upshot of a series of other factors such as members' knowledge repository diversity, time structuring, and social structure of the group, future studies can aspire to promote diversity through the user interface (Curseu et al. 2007). Moreover since facilitation has been found to be an effective intervention method for boosting productivity (Shepherd *et al*. 1996), it is desirable to study implementation of facilitation mechanisms through user interface which may prove useful in distributed groups.

An advancement of the current theory could be the identification of user interface attributes other than those discussed here and empirical studies of their effect on ideation integration within groups. Some examples of the attributes are structuring presentations of ideas on the screen (several windows instead of one; e.g., Dennis *et al*. 1996), threading feature, and font size (e.g., digg), or color (McNab 2009).

Moreover, future theoretical and empirical studies on how the user interface may be instrumental in reducing several forms of opportunism that occur within brainstorming groups (e.g., free riding, social loafing, and motivation loss) and enhance idea generation, sharing and integration within groups will be complementary to the current research (Pinsonneault *et al.* 1999; Shepherd *et al*. 1996; Zhou & Shalley 2007). An important IS research area where motivation poses some limitations on the current theory is the study of idea integration in groups and teams where traditional incentive mechanisms are not present. It is also important to note that a wide range of individual and social structure characteristics typically influence individual idea integration behavior (Gruenfeld *et al*. 1996; Rulke & Galaskiewicz 2000), and it is expected that an examination of individual-specific characteristics will advance theory building in this area.

1.8.Summary and Conclusions

The attention-based theory developed here is based on the fundamental logic of Simon (1947) and the concept of bounded rationality, which stems from individuals' limited capacity for attention. We submit that IS user interface can be instrumental in deploying attentional interventions. The current dissertation also builds upon the cognitive network model of creativity and the ability-motivation framework to link the user interface with human cognition for enabling and motivating individuals to generate integrative ideas. The logical development of this link is a significant achievement for IS research, which has important implications for both IS research and the broader field of organizational science.

The current dissertation's focus is on the potential of technology for supporting attentional process that advances idea integration (Briggs 2006). The proposed theory can inform the design of user interfaces for facilitating idea integration by laying out processes through which visibility and prioritization influence the phenomenon of interest: idea integrations. The theory developed here subscribes to the IS research quest for improving EBS design, productivity, and efficiency through enhancing idea integration in an era when the speed of idea generation and sharing is sharply surpassing that of idea integration and use. Practitioners are thus counseled to carefully craft and choose the user interface features to foster idea integration when desired.

The current dissertation also links the IS user interface to the creation of organizational knowledge-based capabilities through facilitating idea integration within groups. Managing cognitive processes underlying idea integration through IS, therefore, contributes to organization's sustained competitiveness.

CHAPTER 2

LAB EXPERIMENTS

2.1.Introduction

Are shared ideas used? Despite the pervasive use of electronic media for idea generation and idea sharing, the extent and quality of idea integration and use is relatively understudied. This dissertation introduces and empirically examines an attention-based theory of idea integration that underscores the importance of IS user interface design. Building upon Cognitive Network Model of Creativity (CNM) and ability-motivation framework, the proposed theory formulates a causal mode for idea integration in the context of user interface and posits that individuals must be able and motivated to use the ideas that are shared by them by others and integrate them with those of their own. Particularly the dissertation examines the effect of idea visibility and prioritization on idea integration and the extent to which those relationships are moderated by information diversity and group size. The laboratory experiments showed that although communicative idea integration (e.g. mere reference to partners' ideas) increased when visibility increased, elaborative idea integration increased only when visible ideas where highly diverse. Laboratory experiments also indicated that the influence of prioritization on idea integration takes different forms for communicative idea integration and elaborative idea integration. While the effect of prioritization on communicative idea integration is significant through the mediating effect of perceived value of information, the effect of prioritization on elaborative idea integration is significant through the mediating effect of perceived value of idea integration. Full description of the empirical model, hypotheses and the result of the experimental study and its implications are explained in the rest of this chapter.

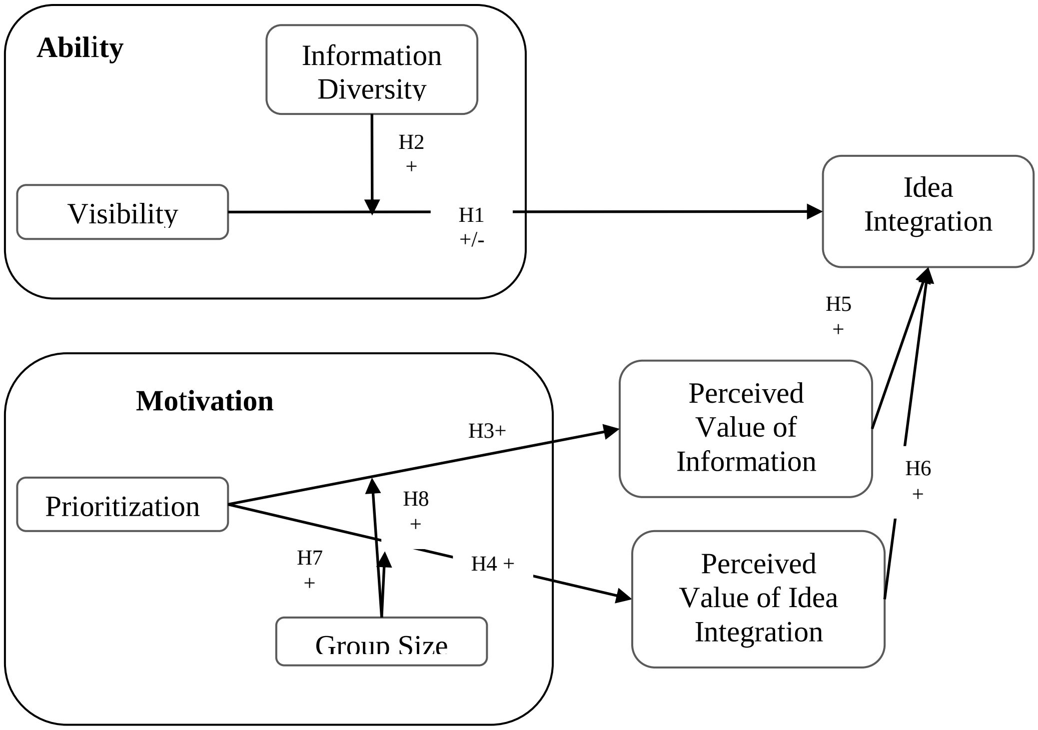


Figure 2.1: Research Model

2.2.Hypotheses

Building on the cognitive network model of creativity and the ability-motivation framework, the current attention-based theory utilizes *visibility* and *prioritization* of ideas as two key mechanisms by which attention to ideas is directed and reinforced (Figure 2.1). Prior empirical studies of idea integration use interventions for directing and switching individuals' attention to enhance elaboration and idea integration (Okhuysen & Eisenhardt 2002; Vreede *et al*. 2000). To advance ability and motivation for idea integration, this dissertation's proposed theory uses visibility and prioritization as two interface-based interventions for channeling brainstormers' attentions (Figure 2.1). Since individuals have been shown to be able to focus only on a limited number of ideas at any given time (Simon 1947), we suggest that only a portion of a larger idea pool will receive effective attention. Therefore ideas generated and sharing during brainstorming compete with each other to receive the brainstormer's attention (Hansen & Haas 2001). For distributing attention among the ideas, chronological order, or rank-based order (order based on collective evaluation of the ideas by the group) are two commonly used methods to organize idea pool on the screen.

2.2.1. Idea Visibility

Visibility of ideas in this paper's proposed theory can be viewed as an interface-based instance of the construct *stimuli quantity per time unit* in the cognitive network model of creativity (Santanen *et al.* 2004). Visibility defines the extent of information that is presented on the screen at any given time. Visibility of the ideas through the user interface facilitates members' exposure to the different dimensions of the shared ideas and thus stimulates activation of associated frames in working memory. According to CNM (Santanen *et al*. 2004), visibility of ideas stimulates search for and retrieval of relevant concepts and thus enables creating connections among those related concepts. Idea visibility is therefore, a predictor of the idea being used in an integration activity when brainstorming is taking place. With the shift from information scarcity to information richness in modern organizations, visibility of ideas becomes even more important (Hansen & Haas 2001) because it identifies the extent to which ideas generated by members of the group are salient to other members.

While the visibility construct, in the current paper, is examined in the context of IS user interface design, it is independent of any particular type of information system technology (Briggs 2006). Visibility is defined by the portion of the idea pool that is visible on the screen at any given time without extra effort (e.g., clicking) and it is posited that visibility plunges as the effort for viewing the ideas increases. Through visibility, individuals' attention is channeled through the user interface where ideas are presented to them and the extent to which the ideas are exposed to the viewers depends on their position on the screen. We suggest that visible ideas influence the focus of attention and in turn influence the extent to which relevant concepts are activated in working memory. Therefore:

Hypothesis 1*: An increase in idea visibility leads to an increase in idea integration.*

We maintain that because of the highly asymmetric nature of the knowledge repositories of individuals, exposure to other individuals' ideas is beneficial. It is important to note that even attending to *ad-hoc* categories and cues provided by others' ideas is beneficial when a problem at hand is unstructured and requires diverse information, which is presumed to be the case in brainstorming. The analysis presented here is based on assumptions that individuals possess heterogeneous knowledge on the subject being discussed and that the subject is beyond any single individual's capability for solving it (Vreede *et al.* 2003), and therefore integration of individuals' ideas is desirable.

It is important to note that based on CNM high levels of stimuli presented to individuals may causes cognitive load (Santanen *et al.* 2004). Similar experimental research studies also found that attending to input from others is detrimental to productivity in brainstorming (Potter & Balthazard 2004). Thus, exposure to ideas of others can at times be beneficial and at times detrimental depending on its extent (Potter & Balthazard 2004).

As ideas that are attended to become more diverse, the potential for integration increases because information diversity will by itself stimulate integration (van Knippenberg *et al*. 2004). Information diversity here represents variety of the ideas or more precisely the variety of information contained in the ideas generated and shared by individuals within the group. This type of diversity has been linked to higher levels of creativity and cognitive complexity

(Harrison & Klein 2007). Information diversity results in diversity of stimuli that draws higher levels of disparity among the concepts that are retrieved from long-term memory (Santanen *et al*. 2004). The higher the disparity among activated concepts in working memory, the higher is the potential for knowledge integration. If knowledge that is possessed and shared by individuals is homogenous or identical, there will be no gain from integration (Grant 1996a). Since integration occurs when different perspectives are combined, *ceteris paribus,* a highly diverse set of visible ideas is more likely to stimulate generation of integrative ideas than a less diverse set of visible ideas. A diverse set of visible ideas contains a diverse set of cues, which may be used for probing memory and thus facilitates retrieval and activation of associatively distant concepts (Santanen *et al*. 2004). Diversity of ideas, therefore, increases the extent to which visibility influences knowledge activation and idea integration. Thus, the gains from controlled visibility should increase with higher diversity of the idea pool. As such, the current paper suggests that diversity moderates the relationship between visibility and knowledge activation:

> ***Hypothesis 2****: Information diversity moderates the relationship between idea visibility and idea integration in that the influence of idea visibility on idea integration is stronger for higher levels of information diversity.*

The cognitive network model of creativity also posits that spreading activation as described in the previous section has automatic and conscious components (Santanen *et al.* 2004). The automatic part occurs without intention and the other requires intention and conscious processing. While visibility in our model has bearings on exposure as an instrument for directing the unconscious part of activation, prioritization appertains to the conscious aspect of spreading activation.

2.2.2. Prioritization

Prioritization in the current paper is defined by using a criterion or a set of criteria for ordering ideas on the screen. The most commonly used prioritization method in verbal brainstorming is collective evaluation by the group. Prioritization based on the collective evaluation of the group is one of the few feasible real-time methods of prioritization in EBS because during brainstorming accurate evaluation of the ideas based on organizational goals (Litchfield 2008) cannot be accomplished. When there is no prioritization, ideas may be displayed on the screen based on their chronological order or ideas may be shuffled on the screen randomly.

The criterion for prioritization, therefore, can be aggregation of individuals' preferences regarding the shared ideas as indicated through a rating scale. Using this method, ideas are prioritized if they are ordered based on the collective ratings by the group. Prioritization based on collective rating is analogous to the use of citation numbers in academic research paper databases to infer the influence of research papers. Many state of the art online discussion platforms use similar mechanisms, such as star rating systems (used in *Amazon.com* reviews or in *Yahoo Answers*). Similarly, file, music, and video sharing and many online newspapers and news aggregators provide individuals with a mechanism to evaluate items and then use the aggregated ratings as a criterion to determine visibility of the items.

To capture an individual's evaluation of others' ideas and an individual's proclivity to idea integration, taking ability-motivation framework, this paper introduces the *perceived integration efficacy* construct. Perceived integration efficacy is defined to encompass (1) individuals' evaluation of others' ideas (perceived value of information); and (2) perception of the gains from idea integration (perceived value of integration). We posit that the criterion for ordering ideas influences an individual's perceived integration efficacy. For instance, if the ideas are prioritized based on the group's collective evaluation, individuals attribute more value to the ideas being displayed. Moreover, prioritization reduces uncertainty in individual decision making for idea integration. It is thus submitted that individual perception of the integration efficacy is higher when ideas are prioritized by the group, and this logic leads to the following proposition:

> ***Hypothesis 3****: Prioritization leads to formation of higher levels of perceived value of information.*
>
> ***Hypothesis 4****: Prioritization leads to formation of higher levels of perceived value of idea integration.*

In summary based on the ability-motivation framework, *Propositions 3 & 4* state that prioritization of ideas on the screen will lead to individual's easy access to the preference of others and consequently influences their motivation for idea integration, which is represented through the two sub-constructs of perceived integration efficacy in our theory. The first sub-construct relates to the belief of an individual regarding the value of the shared ideas (*perceived value of ideas*), which is similar to *information usefulness* (Sussman & Siegal 2003) but is more general than *perceived information credibility* (Dennis 1996), which have been used in prior research studies of information adoption and use. The second sub-construct relates to the perceived value of idea integration, i.e., an individual's belief regarding the extent to which integration contributes to the value of the ideas generated by the individual, which is a new concept introduced in this paper.

According to ability-motivation framework, we posit that, higher levels of perceived value of idea integration will elicit more idea integration, because individuals' actions are generally based upon their beliefs of the consequences of those actions (Simon 1976). Perceived value of information also, has been proven to augment idea use. For instance, the extant literature on information adoption and use suggests that perceived usefulness or credibility or value of the knowledge item will trigger its use and adoption (Sussman & Siegal, 2003). The current paper, thus, posits that:

> ***Hypotheses 5****: An increase in perceived value of information leads to an increase in idea integration.*
>
> ***Hypotheses 6****: An increase in perceived value of idea integration leads to an increase in idea integration.*

It is important to note that prioritization provides a signal that may or may not be sufficiently close to the actual value of the ideas. The discussion of how accurately a particular prioritization method represents the ideas' true values or whether prioritization criteria are moderately or significantly discounted by individuals selecting ideas for integration is beyond the scope of the current paper. The theory constructed here is based on the ability-motivation framework, which posits that the presence of a prioritization mechanism will enhance the total amount of attention allocated to the shared ideas and boost the extent to which they are reviewed and considered.

Similar to many theoretical and empirical research studies of electronic brainstorming (Dennis & Valacich 1999; Dennis & Wixom 2001), group size is considered to be an important moderator of the relationships proposed in the current paper. Particularly, the size of the group is posited to moderate the association between prioritization and perceived integration efficacy. Prioritization here is defined as a mechanism for signaling value or usefulness of ideas (Sussman & Siegal 2003) which is a method for ordering ideas on the screen as well. In larger groups, for example, more people are available for evaluating an idea (Gallupe *et al*. 1992) therefore prioritization based on the collective evaluation of the idea will be more credible in larger groups than it is in smaller groups. Assuming that individuals take the peripheral route for information processing (Petty & Cacioppo 1986) the extent to which the preferences of others is discounted is expect to be less when the group is larger. Thus, there will be more gain in terms of the perceived integration efficacy. Moreover, since in general the idea pool is expected to be larger for larger groups, prioritization has more of an intense effect on ordering ideas in larger groups (wider range of positions on the list of ideas) and has less of an effect in smaller groups. As such, group size is an important moderator in the model:

> ***Hypotheses 7****: Groups size moderates the relationship between prioritization and perceived value of information in that the positive effect of prioritization on perceived value of information is stronger for larger groups.*
>
> ***Hypotheses 8****: Groups size moderates the relationship between prioritization and perceived value of idea integration in that the effect of prioritization on perceived value of idea integration is stronger for larger groups.*

Now that the discussion of the proposed empirical model and hypotheses and moderators has concluded, the report of our experimental study follows.

It is important to note that although many experimental studies have addressed individual's idea-sharing behavior in electronic settings limited research has been done to examine the extent to which individuals build on the ideas shared by others. The experimental design for examining idea integration, however, could benefit from previous experimental examination of electronic brainstorming. As we describe in the following section, software design, task, and scoring system are chosen based on prior empirical research in this area.

Measurement of independent variables such as information diversity and dependent variable, idea integration, however, pose new challenges. As described in the first chapter, Idea integration (also referred to as adoption, exploitation, combination or synthesis) occurs when dimensions of more than one individual's ideas are combined to create new ideas (Davidson et al. 2007). An idea in this dissertation was defined as a statement that consists of at least one testable proposition (Harrison et al. 2007). Idea dimensions, which are building blocks of idea integration, are defined as "unique testable propositions". Some examples from the statements exchanged in experimental sessions are included in Table 2.1. An example of a one-dimensional idea is "I think some sort of tarp would be useful for shade and shelter". A multi-dimensional idea could be "some sort of outer shell jacket that is water proof, can be used to collect water if it rains, covers body at night". "We have to stick together though" is an example of a value statement which is not counted as an idea. More examples on coding the statements exchanged during experimental statements are available in Table 2.1. A sample experimental transcript on which ideas and idea integration instances are marked can be found in Appendix D.

Table 2.1. Statements and Ideas

Description	Example from Experimental Sessions
One-dimensional idea	I think some sort of tarp would be useful for shade and shelter
Multi-dimensional idea	Some sort of outer shell jacket that is water proof, can be used to collect water if it rains, covers body at night
Mere description of facts (<u>not</u> counted as an idea)	-What about the money we have, we each have 2.83 in change...plus $85 in bills -Well we are 65 miles off course and we know we are in and S - SW of the mining camp
Value Statement (<u>not</u> counted as an idea)	We have to stick together though.

2.3.Method

Similar to previous Information Systems research examining individuals' behavior in electronic brainstorming groups (Dennis et al. 1996; Santannen, Briggs & Vreede 2004), the propositions outlined in the previous sections were tested in laboratory experiments using an open idea generation task. The idea generation task is based on the desert survival task (Dyer 1987; Johnson & Johnson 1982; Homan et al., 2007). Participants generate ideas on the items they wish to take to help them survive in desert. This experiment has a 3 * 2 * 2 factorial design (visibility: low, medium, high; prioritization: yes, no; group size: small, large) and participants are randomly assigned to participate in different experimental conditions. Participants discuss electronically within groups using an experimental software system which allows for manipulations of visibility and prioritization. More details of the experimental design are described in the following sections.

2.3.1. Experimental Software System

The software system has a screen split horizontally, with the posted ideas displayed across the top. The user types in an idea in the lower section of the screen and submits the idea with a function key. The snapshots of the system are available in Appendix C. The users can rate other posts and also refer to other posts using a function key. The software (was hosted at *ideation-experiment.org*) then stores ideas exchanged during each experimental session and produces reports of experimental transcripts which are used for measuring idea integration. Experimental transcripts includes activity reports of every individual participating in the session such as the number of posts, referrals and the number of the post they have rated.

To motivate active participation during the experiment, each participant has a score which would increase for different activities which contribute to the group discussion including posting an idea, rating other participants' ideas and referring to other participants' ideas. The score of the individual then would influence individuals' chance of winning the lottery. The scoring mechanism which rewards individuals for referring to each others' ideas is intended to promote idea integration in groups. The scoring system however is not varied across different conditions or session therefore they are not expected to interfere with studying of the main effects (visibility and prioritization). This scoring system built into the experimental design is unique in that in addition to rewarding new posts it rewards referring to other posts as well. To the knowledge, no previous research study or real-world example of ideation systems have been designed to reward idea integration since it is relatively difficult to corroborate in real time whether idea integration has occurred or not. Awarding points for actions individuals take which provides them chance to win a lottery will provide a side goal for participants. This side goal will help individuals focus attention on the task and further their effort for performing the desired activities (Madjar & Shalley 2008). The task here is brainstorming and the desired activities in the experimental sessions are idea generation, sharing, rating, and idea integration. The details of the scoring system are explained in the instruction pages which the participants read on their computer before brainstorming starts. The instructions are available in Appendix B.

2.3.2. Participants

Participants were recruited from two upper-level business courses at a large Mid-Western university in the United States and participate in exchange for extra credit with an opportunity to win a lottery. Participants for the pilot studies were recruited from the general population at the same university and were paid for their participation in the experiment. All participants in a particular session participate in the same condition. Participants were randomly assigned to different experimental conditions.

2.3.3. Task

To ensure variation in the levels of idea integration, an open-ended idea generation task is the most suitable choice for examining idea integration (Dennis 1996; Homan *et al.* 2007) because the solution space is large, and thus provides more opportunity for integration. The task used in this study is based on the classic task of desert survival (Dyer 1987) which is modified for the purpose of idea generation (Homan *et al.* 2007). The task poses a survival problem in a desert; and participants are asked to discuss and generate ideas on the items they wish to take to help them survive. An idea may include a new item, a new use for an already proposed item, or follow-ups to and counter-arguments of ideas that have already been suggested. An idea could include a new item, or a new use for an already proposed item. Participants were instructed that the suggested item (a) should be portable, and (b) participants should explain why the selected items are important for surviving in the situation explained to them. Detailed information about the task is available in Appendix B.

2.4.Treatments

This experiment used a three (Visibility low, medium, and high) by two (no Prioritization, with Prioritization) by two (small groups, large group) factorial design (Figure 2). Visibility is varied by setting the number of posts that are displayed on the screen at any given time. Users can view other posts by navigating through different pages.

Table 2.2: Number of Groups in Each Experimental Condition

	Small/ Large	Small/ Large
Low Visibility	(4)/ (10)	(17)/ (12)
High Visibility	(4)/ (6)	(6)/ (6)
	No Prioritization	With Prioritization

No prioritization means that posts are displayed based on reverse chronological order and *with prioritization* means that posts are displayed prioritized based on the collective evaluation of the users.

Groups working in each of the six conditions were given the desert survival task as stated above, and spent fifteen minutes generating ideas on what items to carry for surviving in desert using the electronic the software described above. To confirm the effectiveness of the visibility, a post-task questionnaire item asked group remembers how they thought about the number of posts on the screen.

2.4.1. Procedures

Each session was approximately thirty minutes long. Participants signed an attendance sheet when they arrived, and then seated themselves on one of computers in cubicles in the experiment's room. The experimenter briefed participants on the experiment for about five minutes. It was important for all the groups in the study to start with a similar understanding of the task and the system. Therefore, the experimenter read a pre-specified set of statements for participants which ended by three notes on frequently asked questions. The participants then read four instructions pages on computers for about ten minutes and were allowed to ask questions of clarification. Participants then used the discussion forum of the system to generate and exchange ideas and discuss the actual survival situation for fifteen minutes. Participants are asked to discuss for twenty five minutes within group and list as many ideas as they can on the items they wish to take that help them survive.

2.4.2. Pilot Tests

To confirm the effectiveness of the visibility, a 7-point Likert scale post-experiment questionnaire item asked group remembers how they thought about the number of posts on the screen:

What do you think about the numbers of posts displayed on the screen?

1: Too few; 7: Too many.

Based on the recommendations for cross-level analysis (Rousseau 1985), the level of analysis for all questionnaire items is at the group level. Therefore, to test the effectiveness of the visibility manipulation (low vs. medium vs. high) the mean of the group members' responses should be used. The mean and standard deviations at group level is used for identifying the three levels of visibility during the pilot testing. As shown in Table 2.3, three levels of low visibility, two levels of medium visibility, and two levels of high visibility have been tested. Based on the observations, low, medium, and high visibility are set to 5, 12, and 25.Analysis of Variance (ANOVA) of the manipulation checks after actual tests should also reveal a main effect for visibility was present.

Table 2.3: Manipulation Checks

Number of groups	Visibility Manipulation	MC (AVG, SD)
1	Low at 3	(3,-)
2	Low at 5	(3.625,0.177)
2	Low at 7	(3.875, 1.237)
4	Medium at 12	(4.437, 0.768)
2	Medium at 15	(4.45,1.12)
2	High at 20	(4.791,1.258)
2	High at 25	(5.25,0.567)

To test the effectiveness of the prioritization manipulation a 7-point Likert scale post-experimental questionnaire item asked group members how they perceived the order in which posts were displayed on the screen.

How did you perceive the order in which posts were posted on the screen?
1: were not prioritized based on their value; 7: were prioritized based on their value

The flat structure (all posts appear at the same level on the screen) used in the pilots revealed that manipulation of prioritization might have an unwanted effect of cutting the chain of discussion. Therefore software system was modified to include threading feature. By adding threading feature, prioritization of the parent post on the screen and subsequent change in position will automatically influence all the connected posts to the parent post. A summary of observation during the pilot tests is reported in Table 2.4.

Table 2.4 : Summary of the data collected in pilot tests

ID	Group Size	Condition	# of posts	# of ideas	# of referrals
1	2	(1)	42	23	11
2	4	(5)	41	28	15
3	6	(5)	105	51	5
4	4	(3)	46	23	8
5	4	(2)	41	21	9
6	4	(1)	46	21	7
7	4	(3)	72	25	11
8	3	(2)	38	14	7
9	3	(2)	37	19	6
10	4	(3)	41	22	11
11	4	(1)	60	30	11
12	3	(3)	32	20	7
13	4	(2)	73	35	19
14	4	(1)	93	37	9
15	4	(3)	76	21	4
16	4	(1)	102	25	21
17	3	(2)	23	18	9

According to the finding of the pilot tests, visibility will be set to 7 (low), 12 (medium), 25 (high). Prioritization will be manipulated on a threading-enabled discussion system so that all the posts that comprise a discussion thread automatically change position on the page when the original post changes position. The coding scheme adopted for analysis of the session transcripts is included in the next section.

2.5. Experiments, Measurement and Coding

Two hundred and twenty six students participated in 65 experimental sessions. Number of groups in each experimental condition was the same as indicated in Table 2.2. Details of measurement are explained in the following subsections.

2.5.1. Identifying Unique Ideas and Idea Integration Levels

All the posts in each experimental session transcript were examined. All posts containing an idea as defined earlier in this chapter and show in Appendix D are counted towards the total number of ideas. Two external coders who were blind to the experimental conditions were asked to code transcripts of the experimental sessions. The coders were asked to first read the entire transcript to understand how the discussion flowed among the individuals in the group. The coders then were asked to read each statement that was exchanged by individuals and coded them as idea generation or integration, as shown in Table 2.5.

The coders then were asked to read each statement that was exchanged by individuals and completed a row in the coding table with the following information:

- # of unique new items
- Is the item justified?(Are reasons included]
- Challenge of, query to someone else's idea without providing any reason: level 1
- Approving somebody else's idea without providing any additional: level 1
- Challenge of, query to someone else's idea: with reason but without: level 2
- Approving somebody else's idea and providing additional: level 2
- Alternative to/improvement of an existing idea? level 3
- Other: if none of the above applies.

Table 2.5: Coding Different Levels of Idea Integration

Description/Definition	Example from Experimental Sessions
Communicative Idea Integration	
Challenge without reason: challenge of, query to someone else's idea without providing any reason	P1: Take a cooler P2: why?
Approve without additional reason: approving somebody else's idea without providing any additional reason/justification.	P1: maybe some kind of solar powered flashlight to use with the compass for nighttime travel P2: I think the flashlight idea is good
Elaborative Idea Integration *Type 1:*	
Challenge with reason: challenge of, query to someone else's idea: with reason but without providing alternatives.	P1: Medical first aid kit from plan P2: but they said we weren't hurt
Approve with reason: approving somebody else's idea and providing additional reason/justification.	P1: I think in the middle of nowhere map might be better P2: yes, especially if we are in a zone with no reception
Type 2:	
Alternative: alternative to or improvement of an existing idea.	P1: How about a flashlight for when it gets dark? P2: maybe some kind of solar powered flashlight to use with the compass for nighttime travel

More examples of each of the categories shown in Table 2.5 are available in Appendix D and Appendix E. For each experimental session we computed the total number of each type of idea integration and normalized the total number of idea integration over the total number of posts exchanged during that experimental section. The three levels coding of idea integration is a simplified version of the seven-level integrative complexity coding (Backer-Brown et al. 1992) which is shown in Appendix A.

2.5.2. Perceived integration efficacy

Perceived integration efficacy is measured with the two sub-constructs of *perceived value of information* and *perceived value of knowledge integration*. Each of the two sub-constructs is measured with four 7-point Likert scale post-experiment questionnaire items. Perceived integration efficacy sub-constructs measurement items are:

1. Perceived Value of Information (Dennis 1996)
   - *I am not sure that all the ideas that others contributed had much value.*
   - *Some people did not post valuable ideas.*
   - *I am not sure I completely attributed value to every idea that was posted by others.*
   - *I am convinced that all the ideas everyone posted was valuable.*

2. Perceived Value of Idea Integration (developed in this study)
   - *Combining my ideas with ideas posted by others created better ideas.*
   - *I am not sure if using ideas posted by others has helped me generate better ideas.*
   - *I am convinced if I use ideas posted by other people I can create better ideas.*
   - *Using other peoples' ideas has not helped me create better ideas.*

The reliability analysis for the measurement items for *perceived value of information* and *perceived value of knowledge integration* was performed for 11 groups in pilot tests with the Cronbach's alpha being 0.761 for the first and 0.68 for the latter.

The reliability analysis for the two sub-constructs for all the cases in pilot tests and experiments are also recorded in Table 2.6

Table 2.6 : Reliability Statistics

	Cronbach's Alpha	N of Items
Perceived Value of Information (PVI)	.719	4
Perceived Value of Knowledge Integration (PVII)	.733	4
Number of cases: 226		

2.5.3. Information Diversity

As described in Chapter 1, information diversity in this dissertation represents variety of the ideas or more precisely difference in information contained in the ideas generated and shared by individuals within the group. Diversity of ideas leads to increased diversity of cues, which in turn, facilitates knowledge activation and retrieval of more information from memory. Because of measurement complications, knowledge activation is not measured directly. Thus in the empirical study, information diversity is examined as the moderator of the direct link between idea visibility and idea integration.

Prior empirical studies of EBS have manipulated information diversity by using hidden-profile tasks in which information is unevenly distributed among participants. Therefore EBS literature provides little insight for measuring information diversity. In this study, information diversity, is measured by latent semantic analysis (LSA) (Landauer & Foltz & Laham 1998). For each experimental session we computed a LSA measure between any two posts using the system available at *http://lsa.colorado.edu/*. The average of all binary LSA measures in a session was used as information diversity measure. An example of LSA numbers for one of the experimental sessions in which statements are exchanged is available in Appendix F. Since LSA is symmetric, the matrix is diagonal. For each experimental session we computed LSA measure between any two posts using the system available at *http://lsa.colorado.edu/*. The one minus the average of all $\frac{n(n-1)}{2}$ binary LSA measures in a session was used as information diversity measure. LSA numbers which represent similarity are then converted to represent diversity.

2.6.Dependent Variable:

To account for variation in group members' enthusiasm and energy for participating, the number of idea integration instances will be normalized by dividing it into the total number of ideas minus one. The rationale for deducting the number of ideas generated is deducted by one is that the first statement during brainstorming cannot be an integrated statement (Vreed *et al.* 2000). Integration coefficient is thus calculated by dividing the number of unique integrated ideas by the number of unique ideas generated during the brainstorming. To normalize measures we used averaged number of ideas over the group size to get idea-per-person for each experiment. This is based on the approach used in the previous studies of information elaboration in which elaboration-per-person used.

2.7.Preliminary Analysis

Before conducting Structural Equation Modeling analysis, a series of analysis of variance examination was conducted on the data set. Summary of the data is available in Table 2.7.

Table 2.7: Descriptive Statistics for Six Treatments

Condition	Stat	Mean	Std. Dev.	Min.	Max.
Low Visibility Small Group (count:10) Large Group (count:9)	Posts	30.9 51.22	8.37 21.78	21 24	47 92
	#unique ideas	19.6 22	5.62 6.58	11 12	29 31
	Integ. L1	3.1 5.67	3.41 2.45	0 2	10 9
	Integ. L2	4.5 16.89	3.63 11.02	0 6	12 41
	Integ. L3	2.5 6.89	1.35 4.99	0 1	5 17
Medium Visibility Small Group (count:12) Large Group (count:15)	Posts	30.25 44.4	11.88 15.29	14 23	52 74
	#unique Ideas	19.67 21.73	6.17 4.62	13 14	35 30
	Integ. L1	2.5 5.67	1.83 3.87	0 0	6 13
	Integ. L2	6.5 12.47	4.62 7.5	0 0	15 28
	Integ. L3	3.33 4.53	2.93 2.97	0 0	9 11
High Visibility Small Group (count:9) Large Group (count:10)	Posts	39 48.2	12.45 18.95	22 27	58 81
	#unique ideas	20.33 23.80	5.87 5.50	13 11	28 39
	Integ.L1	5.33 5.50	4.8 3.47	0 1	13 11
	Integ. L2	8.78 11.7	6.53 3.8	0 6	16 18
	Integ. L3	3.67 5.6	3.39 3.6	0 1	11 13

2.7.1. Testing the Effect of Idea visibility and Information diversity on Idea integration

The 2-way ANOVA of sum of communicative and elaborative idea integration on visibility (L,M,H) or group size (S,L) showed no significant effect for visibility or group size. Similarly, the two 2-way ANOVA of sum of communicative and elaborative idea integration on visibility (L,M) and group size (S,L) showed no significant effect for visibility or group size. Therefore we decided to examine each level of idea integration separately. The next step was to conduct three 2-way ANOVA for different types of idea integration on Visibility (L,M) and Size (S,L) and three 2-way ANOVA on, Visibility (M,H) and Size (S,L). The above 2-way analyses of variance showed that group size was not a statically significant predictor for any of the three types of idea integration (Figure 3). Furthermore the first three 2-way ANOVA models showed that there was significant difference among the three types of idea integration between medium and high visibility groups but no significant difference among the three integration types between low visibility groups and medium visibility (Figure 2.2). As such for further analysis, we combined the low and medium visibility groups.

We then conducted three ANCOVA to examine the influence of idea visibility and group size on the three types of idea integration when information diversity was included as a covariate. The three ANCOVA models consisted of two visibility types (L&M combined, H) and two group sizes (S, L). Consistent with the findings of ANOVA (Figure 2.3), ANCOVA showed even lesser effect for group size after taking out the variance accounted by information diversity. The difference between communicative and elaborative was different for visibility types (L+M) and (H) at 0.05. The direction of the difference is depicted in Figure 2.3.

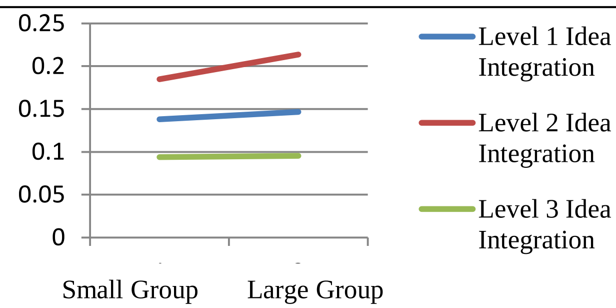


Figure 2.2: Three Levels of Idea Integration for Small and Large Groups

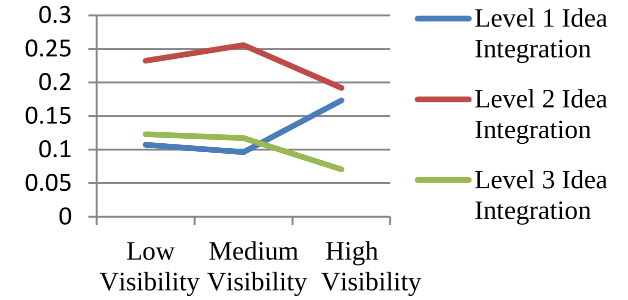


Figure 2.3: Three Levels of Idea Integration for Different Visibility Levels

Based on the findings from ANOVA and ANCOVA, the group size was not considered a predictor and groups with low and medium visibility were combined. A regression analysis on the sum of type 1 and type 2 of elaborative idea integration was conducted to test for idea visibility effect with moderating effect of information diversity. The coefficient for the interaction term was statistically significant ($p<0.05$). Given that visibility is negatively related to elaborative idea integration, and smaller diversity is represented by larger number of LSA, the negative coefficient of the interaction terms imply that the higher the diversity, the less detrimental is the effect of visibility (the less decrease in idea integration). Similarly the analyses of communicative integration showed positive relationship with visibility ($p<0.05$) with a marginally significant effect of diversity. Therefore as hypothesized earlier in this dissertation communicative idea integration was found to be positively associated with idea visibility but because of cognitive overload, elaborative idea integration type 1 and type 2 were found to be negatively associated with visibility thus the coefficient is negative for idea visibility. Also information diversity was not expected to have any particular relationship with idea integration, and only the interaction of information diversity and idea visibility found to have an effect.

Similarly, the ANOVA conducted to compare group with prioritization and groups w no prioritization. The ANOVA results indicated that prioritization is a significant factor for compared perceived integration efficacy. Thus in the SEM model only perceived integration efficacy measures have been included. The above analysis did not consider prioritization in the analysis.

2.8. Structural Equation Model

To test the structural model and the measurement model the data collected from the experimental sessions were analyzed using the structural equation modeling (SEM). SEM is best suited for testing our research model because it allows simultaneous assessment of structural and measurement models and also the multi-step paths (Gefen, Straub, & Boudreau 2000). The SEM model was developed and examined with Warp3 PLS software that applies the partial least squares (PLS) technique (http://www.scriptwarp.com/warppls). PLS is particularly chosen to test our research model because it is well suited for exploratory research and theory development (in contrast to theory testing with LISREL for example).

Since this paper presents an exploratory research, we setup two distinct SEM models and examined them in WarpPLS. Each model represents a unique approach to treating our research model for the dependent variable, idea integration. In the first model, we test for the model's proposed visibility-prioritization effects on idea integration when the total numbers of communicative and elaborative idea integration as described in previous sections are represented in a single construct of idea integration. The first model, including the coefficients and p-values are depicted in Figure 2.4. The second model treats communicative and elaborative idea integration as two separate independent variables. Model 2 is depicted in Figure 2.5.

The theoretical rationale for creating the two models and for treating communicative and elaboration idea integration as two separate constructs in the second model is described next.

Also the two models, the path coefficient within each and the consistency of the findings with our research model (Figure 2.1) are described in detail in the following subsections.

2.9.SEM Model 1

Figure 2 illustrates our first SEM model. This model is identical to the paper's research model which was laid out in Section 1&2 (Figure 2.1). In this model idea integration is represented as a single construct. This single construct is measured by the total number of all idea integration instances in a specific experimental session. All idea integration instances include communicative idea integration and elaborative idea integration (Type 1 and Type 2). The model fit statistics are available in Table 2.8.

Table 2.8 : Model Fit Indices and P-Values

Average Path Coefficient (APC)	0.258 P<0.001
Average R-Squared (ARS)	0.319 P<0.001
Average Variance Inflation Factor (AVIF)	1.128 (good if <5)

It is generally recommended that the p-values be lower than 0.05 for the average path coefficient (APC) and the average r-squared (ARS). The average variance inflation factor (AVIF) is also expected to be lower than 5 (Kock 2009) for the models that fit well with the data. All the three fit indices for Model 1 as shown in Table 2.8 satisfy the requirements of a good fit.

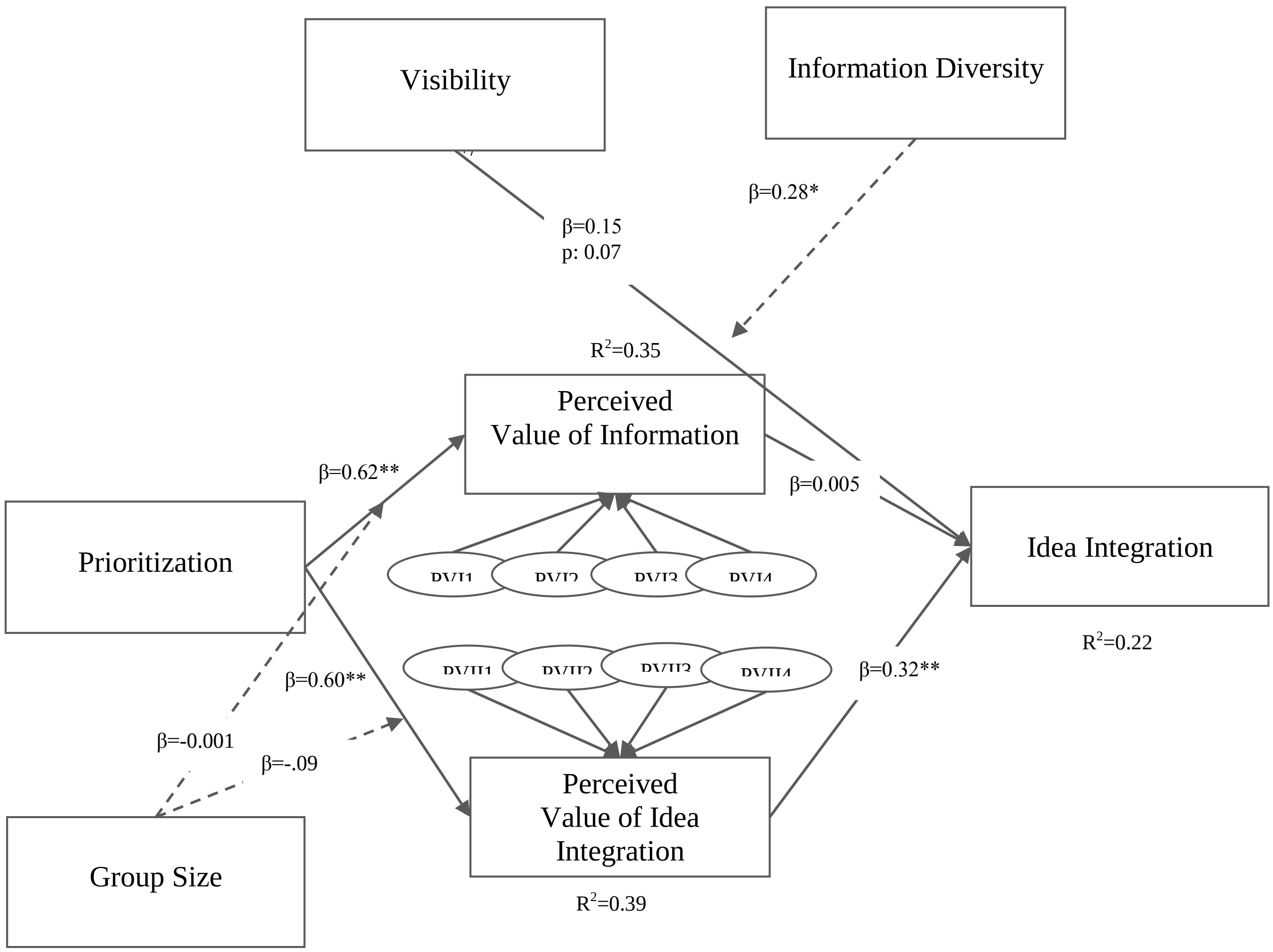


Figure 2.4: SEM model for idea integration

*: p<0.05
**: p<0.01

2.9.1. Measurement Model

The two latent variables, perceived value of information and perceived value of idea integration are each measured by four items. Perceived value of information measured by PVI1 to PVI4 and perceived value of idea integration measured by PVII1 to PVII4 (items described in section 2.5.2). Therefore to assess the factorial validity of a reflective construct, we conducted convergent and discriminant validity tests. Convergent validity is the extent to which items reflect one particular construct (Straub *et al.* 2004). The loadings of the measurement items for both perceived value of information and perceived value of idea integration are available in Table 2.9.

Table 2.9 : Factor Loadings

Perceived Value of Information (PVI)		Perceived Value of Idea Integration (PVII)	
PVI1	0.822	PVII1	0.917
PVI2	0.911	PVII2	0.883
PVI3	0.796	PVII3	0.826
PVI4	0.830	PVII4	0.873

The factor loadings as depicted in Table 2.9 are all above the recommended threshold of 0.5 ($p<.001$) (Hair, Anderson, & Tatham 1987). Thus we conclude that all measurement items, PVI1 to PVI 4 and PVII1 to PVII4 well represent their correspondent construct of perceived value of information and perceived value of idea integration. The reliability analysis showed that Cronbach's alpha was 0.861 for perceived value of information and was 0.898 for perceived value of idea integration (Number of cases: 226). The Cronbach's alpha values for both constructs are above the recommended threshold of 0.7 (Fornell & Larcker 1981). The composite reliability was 0.906 for perceived value of information and 0.929 for perceived value of idea integration. Based on the above analysis, therefore, PVI1 to PVI4 exhibit acceptable convergence toward the perceived value of information. Similarly PVII1 to PVII4 exhibit acceptable convergence toward the perceived value of idea integration.

Lastly, we examine discriminate validity for the measurement items of perceived value of information and perceived value of idea integration. Discriminant validity is the extent to which measurement items represent their suggested construct differently from the relation with all other items in the measurement model (Straub *et al.* 2004). We thus expect that square root of the average variance extracted (AVE) for perceived value of information and perceived value of idea integration be larger than any other correlation involving the two latent variables (Fornell & Larcker, 1981). We've recorded an AVE of .840 for perceived value of information which is higher than other correlations involving perceived value of information (≤ 0.622). We also recorded an AVE of .875 for perceived value of idea integration which is higher than any other correlation involved perceived value of idea integration (≤ 0.593). The above test results suggest that the PVI1 to PVI4 and PVII1 to PVII4 measurement items distinctively reflect perceived value of information and perceived value of idea integration.

2.9.2. Structural Model

The results of the SEM analysis with respect to our research hypotheses1-8 (Figure 2.1) are described in this section. First the path between idea visibility and idea integration (Hypothesis 1) was marginally significant ($\beta=0.15$; $p=0.07$). As such we cannot make a conclusive statement that the data was consistent with our hypothesis that higher visibility leads to increased idea integration. Second the moderating effect of information diversity on the path between idea visibility and idea integration (Hypothesis 2) was found to be significant ($\beta=0.28$; $p<0.05$). This implies that the interaction term, idea visibility*information diversity, was a significant predictor for idea integration.

The finding of SEM analysis of Model 1 was also consistent with Hypotheses 3-4. SEM analysis found that prioritization was a significant predictor of perceived value of information and perceived value of idea integration. Both constructs were found to be positively associated with prioritization and the path coefficient were statistically significant ($\beta=0.62$; $p<0.01$; $\beta=0.60$; $p<0.01$). Also, the correlation between perceived value of information and perceived value of idea integration is 0.593 which was also statistically significant ($p<0.01$).

The result of SEM analysis of Model 1 was not consistent with Hypothesis 5. The path coefficient ($\beta=0.005$) for the link between perceived value of information and idea integration was not significant. The data, however, was found to be consistent with Hypothesis 6. The path coefficient for the link between perceived value of idea integration and idea integration was significant ($\beta=0.32$; $p<0.01$).

SEM analysis found no evidence consistent with the hypotheses 7-8 concerning the moderating effect of group size in the path between prioritization and perceived value of information and perceived value of idea integration. The path coefficient for the moderating effect of group size on link between prioritization and perceived value of information was small and non-significant ($\beta=-0.001$). The same was true for the moderating effect of groups size on the link between prioritization and perceived value of idea integration ($\beta=-0.09$). As such our laboratory experiment was not helpful in corroborating the relationships proposed in Hypotheses 7 and 8.

The quest to get a more precise perspective on the possible distinct features of communication and elaborative idea integration led us to create and analyze a second SEM model. In Model 2 which is depicted in Figure 2.5, communicative and elaborative idea integration were treated as two separate variables. Although prior research on idea integration in IS literature has treated communicative and elaborative idea integration in the same way we believe there are some theoretical difference that justify separating the two constructs.

Communicative idea integration and elaborative idea integration are different in cognitive requirements and motivational factors. These cognitive and motivational differences may alter the influence of user interface features on communicative and elaborative idea integration. Communicative idea integration represented in our study by mere reference to other peoples' ideas. The reference may occur in forms of acknowledging contributions of others, via either recognizing them or criticizing them. Communicative idea integration is proposed to have value with respect to recognizing ideas (Vreede *et al.* 2000) of others but require less attention to the shared ideas when compared to elaborative idea integration. It also requires relatively less cognitive engagement in the information involved in ideas of others. Elaborative idea integration (Type 1) in this study is represented by acknowledging other peoples' ideas and elaborating on the reasons why the ideas are criticized or recognized. Elaborative idea integration (Type 2) may also involve providing alternatives to or an improvement over other peoples' ideas. We propose that elaborative idea integration may require higher types of attention and more cognitive involvement and effort.

As such we conducted a second structural model in which communicative idea integration and elaborative idea integration are represented by two separate constructs. The SEM Model 2 is depicted in Figure 3 and the summary of the path coefficients and their statistical significance and implications for our research follow.

2.10. SEM Model 2

Model 2 is illustrated in Figure 2.5. Model fit statistics numbers are available in the following tables. The p-values for the average path coefficient (APC) and the average r-squared (ARS) is less than 0.05. The average variance inflation factor (AVIF) is lower than 5 All the three fit indices for Model 2 as shown in Table 2.10 satisfy the requirements of a good fit (Kock 2009). In the next subsection we describe and contrast the path coefficients for communicative and elaborative idea integration with respect to each hypothesis.

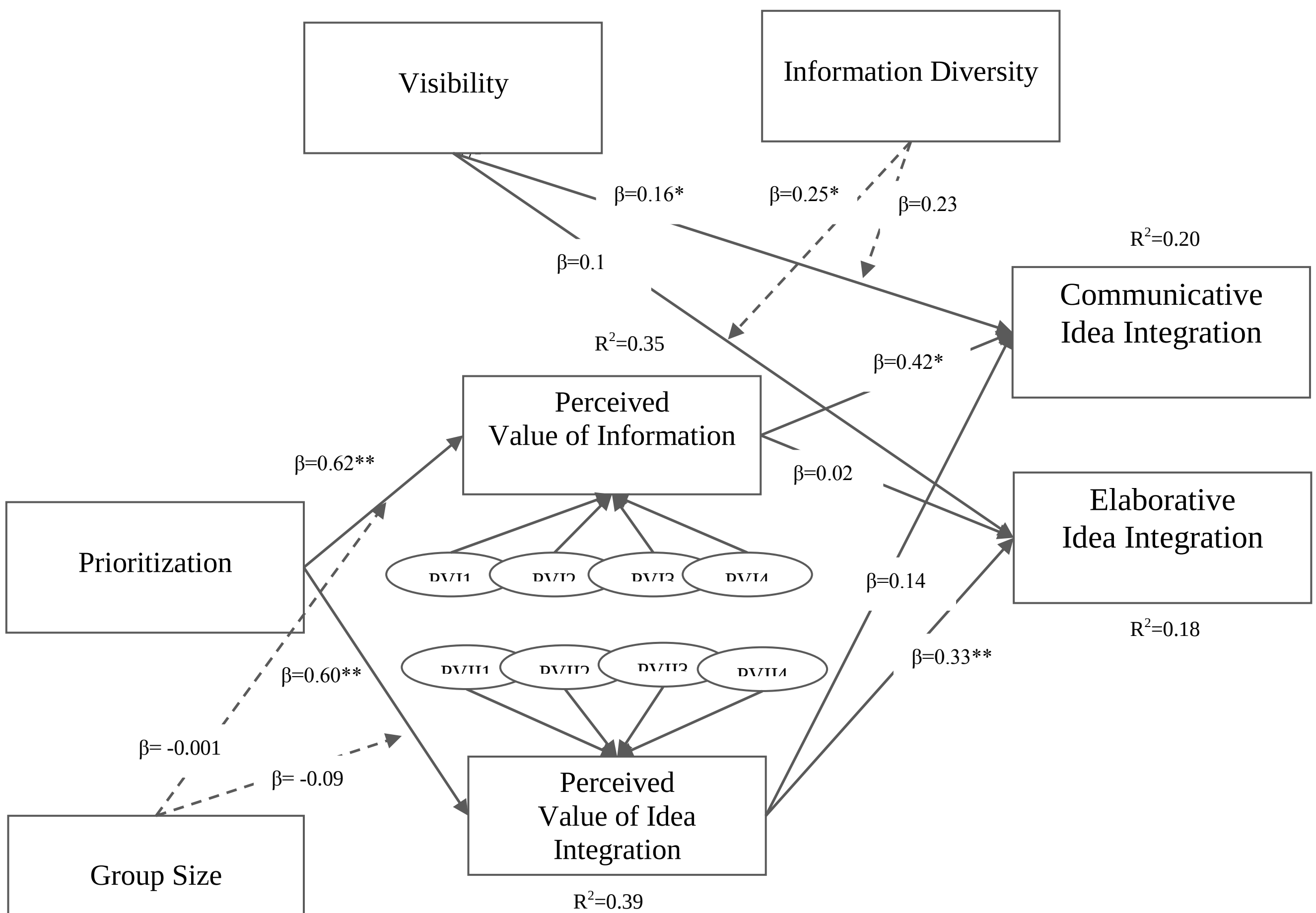


Figure 2.5: SEM Model with Levels of Idea Integration Separated

*: $p<0.05$
**: $p<0.01$

Table 2.10 : Fit Statistics

Average Path Coefficient (APC)	0.247 P<0.001
Average R-Squared (ARS)	0.281 P=0.003
Average Variance Inflation Factor (AVIF)	1.124 (good if <5)

2.10.1. Structural Model

It is important to note that measurement model in Model 2 is the same as that in Model 1. Therefore the analysis of measurement model will be the same as the one in Model 1 and is not repeated here. To examine the structural model we look at the path coefficient for all the structural links proposed in the second model.

First, the SEM analysis found out that the path coefficient for the link between idea visibility and communicative idea integration was significant ($\beta=0.16$; $p<0.05$). However, the path coefficient for the link between idea visibility and elaborative idea integration was not significant ($\beta=0.1$). This indicates that in our dataset higher idea visibility contributes to an increase in communicative idea integration but does not influence the extent of elaborative idea integration. The current data set, thus, was consistent with Hypothesis 1 for communicative of idea integration but was not consistent with Hypothesis 1 for elaborative idea integration

Second, the moderating effect of information diversity on the link between idea visibility and communicative idea integration was not significant ($\beta=0.23$). The same moderating effect was significant for the link between idea visibility and elaborative idea integration ($\beta=0.25$, $p<0.05$). In other words, the interaction effect of information diversity and idea visibility on idea integration was significant for elaborative idea integration, and non-significant for communicative idea integration. The significant effect of the interaction term, information diversity * idea visibility, implies that elaborative idea integration was associated with idea visibility only when information diversity was high. Therefore, the findings of the SEM for this paper's dataset were consistent with Hypothesis 2 for elaborative idea integration but not for communicative idea integration.

In summary the SEM results for Hypotheses 1&2 indicated a distinction between communicative and elaborative idea integration with respect to the effect of idea visibility and information diversity on them.

As expected, the effect of prioritizations on perceived value of information and perceived value of idea integration in Model 2 is the same as those in Model 1. The path coefficients for the link between prioritization and perceived value of information ($\beta=0.62$, $\rho<0.01$) and perceived value of idea integration ($\beta=0.60$, $\rho<0.01$) were both significant. Thus as found previously, the experimental data is fully consistent with the relationships formulated in Hypotheses 3&4.

The distinction between communicative idea integration and elaborative idea integration once again becomes evident when corroborating hypotheses 5 & 6. SEM analysis showed that communicative idea integration is positively associated with perceived value of information ($\beta=0.42$, $\rho<0.05$) and the effect is significant. But the link between perceived value of information and elaborative idea integration was not significant ($\beta=0.42$). The above two path coefficients indicate that this paper's data is consistent with Hypothesis 5 for communicative idea integration. The data, however, does not provide any information for corroborating Hypothesis 5 for elaborative idea integration.

The SEM analysis also found out that elaborative idea integration is positively influenced by perceived value of idea integration ($\beta=0.33$, $\rho<0.001$) and the effect is significant. But the link between perceived value of idea integration and communicative idea integration was not significant (β=0.14). The above results indicate that this paper's data is consistent with the proposed relationships in Hypothesis 6 for communicative idea integration but does not provide any information for corroborating Hypothesis 6 for elaborative idea integration.

As expected, similar to Model 1, the moderating effect of group size on the link between perceived value of information and perceived value of idea integration in Model 2 is the same as those in Model 1 (β=-.001; β=-0.09). Both path coefficients are non-significant. Therefore this paper's data does not provide any information for corroborating Hypotheses 7&8. As such the understanding of this interaction effect is not further by the empirical study which was conducted in this paper.

Full analysis of Model 1 and Model 2 as described above provided evidence for this paper's call for recognizing different types of idea integration in theoretical studies and empirical examinations of idea integration. In the next section the implications of the findings from Model 1 and Model 2 are discussed in detail.

2.11. Discussion

The SEM analysis of Model 1 and Model 2 has yielded some unexpected yet interesting results. For example, the effect of visibility on the idea integration was marginally consistent with hypothesis 1's prediction in Model 1 when idea integration was treated as a single construct. The result of the Model 2 analysis however was fully consistent with hypothesis 1 for communicative idea integration. That means that mere exposure to ideas of others increases individuals' likelihood to perform communicative idea integration through acknowledging those shared ideas. A similar statement cannot be made for elaborative idea integration because the results were not consistent with hypothesis 1 for elaborative idea integration. This inconsistency implies that based on the current experimental study, no evidence is available to corroborate that higher idea visibility will lead to an increase in elaborative idea integration.

Model 1 analysis results also showed a significant moderating effect for information diversity on the relationship between idea visibility and idea integration. Further analysis in Model 2 revealed the moderating effect was only present for link between idea visibility and elaborative idea integration. This indicates that diversity of the information contained in the ideas is a significant moderator for the association between idea visibility and elaborative idea integration. It is important to reiterate that although the effect of the interaction term, idea visibility * information diversity on elaborative idea integration was significant; the effect of idea visibility itself on elaborative idea integration was not significant. Therefore this finding for elaborative idea integration means that higher idea visibility leads an increase in elaborative integration if accompanied by information diversity. In summary Model 1 and Model 2 analysis results show that the moderation effect of information diversity as hypothesized in our research model (Figure 2.1) existed for elaborative idea integrations but not for communicative idea integration.

The above different forms of the relationship between idea visibility communicative and elaborative idea integration can inform future research on idea integration. This distinction points to a potential difference in underpinning processes which enable communicative or elaborative idea integration. For instance, if user interfaces are to enhance idea integration, designers should first carefully delineate the form of idea integration that bests fits the task at hand and then create interface features for supporting it. While in some tasks, the mere acknowledgement of other peoples' ideas is desirable (e.g., to encourage members to generate more ideas to achieve higher quantity), in other tasks deeper types may be required to achieve the goal (e.g., quality is preferred over quantity).

The SEM analysis also indicated that interaction term, idea visibility* information diversity was a significant predictor for elaborative idea integration but not for communicative idea integration. This finding will guide the rate by which new and diverse ideas are presented to the brainstormers. For instance, when examining the effect of stimuli rate on the extent of creativity in groups (Santanen *et al.* 2004), the frequency and rate at which cues will be presented to the brainstormers may be tailored via the user interface to better fit the form of idea integration that is desired for particular brainstorming contexts. Similarly, the form of idea integration can inform the decision to choose relay vs. decathlon modes of group brainstorming (Vreede *et al.* 2003; 2010). When elaborative idea integration is desirable, it is expected that relay mode would be more promising. Also when communicative idea integration is more desired, we speculate that decathlon mode would be more beneficial.

The analysis of Model 1&2 also indicated that prioritization has an effect on idea integration. In Model 1, the path coefficient for the link between perceived value of information and idea integration was non-significant but perceived value of idea integration was found to be significant predictor for idea integration. When examined further in Model 2, SEM analysis showed that the indirect link between prioritization and communicative and elaborative idea integration takes two distinct forms. Consistent with our research model (Figure 2.1), the effect of prioritization on communicative idea integration was realized through the mediating effect of perceived value of information. However, contrary to our theory's prediction, the mediating effect of perceived value of idea integration was not significant for the indirect link between prioritization and communicative idea integration. These findings suggest that regardless of individuals' perception of how idea integration may help them generate better ideas, they will engage in the communicative idea integration provided that individuals value the information contained in other peoples' ideas. The relationship between the perceived value of information and communicative idea integration is represented in the following diagram. As part of WarpPLS algorithm, both variables were normalized.

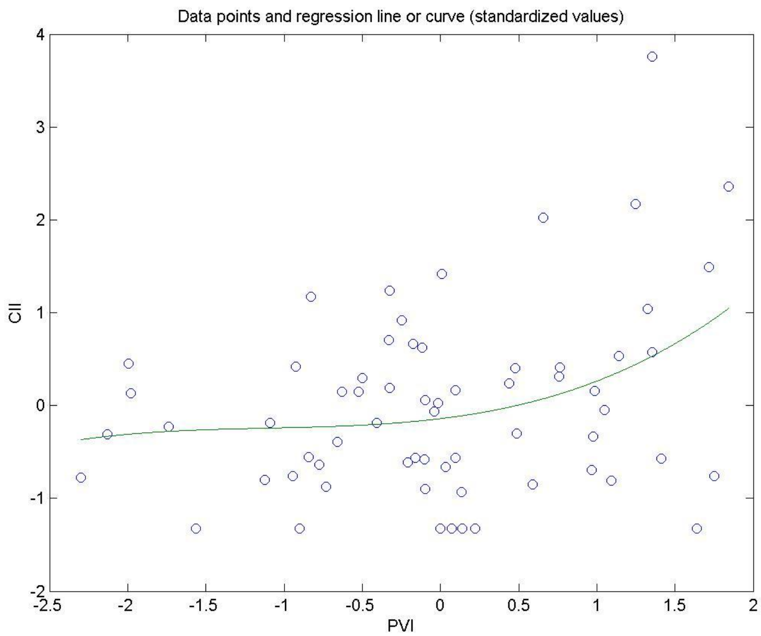


Figure 2.6: Functional Form between Perceived Value of Information (PVI) and Communicative Idea Integration (CII)

The effect of prioritization on elaborative idea integration is realized through the mediating effect of perceived value of idea integration. This effect was consistent with our research model (Figure 2.1). Contrary to our theory's prediction, however, the mediating effect of perceived value of information was not significant for the link between prioritization and elaborative idea integration. An implication of these findings is that regardless of individuals' perception of how valuable other peoples' ideas are, they will engage in the higher types of idea integration if they perceive value in idea integration. The relationship between the perceived value of idea integration and elaborative idea integration is represented in the following diagram. As part of WarpPLS algorithm, both variables are normalized.

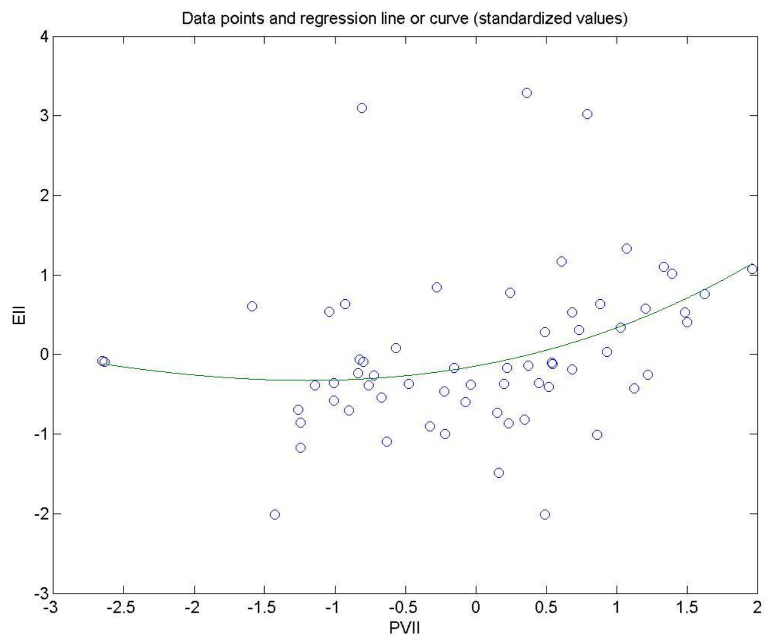


Figure 2.7: Functional Form between Perceived Value of Idea Integration (PVII) and Elaborative Idea Integration (EI)

The non-linear functional forms depicted in Figure 2.6 and Figure 2.7 highlight a relatively more critical role that perceived value of information and perceived value of idea integration play in enhancing idea integration. Previous studies of idea integration point to the environmental factors, interventions and group norms as factors which influence individual's disposition towards idea integration. This study used prioritization as a user interface attribute for enhancing idea integration, and our empirical study found prioritization to be effective.

Prioritization based on the collective evaluations of the participants is the most commonly used methods in verbal brainstorming and one of the few feasible real-time methods of prioritization in electronic brainstorming. Therefore this paper's empirical evidence that prioritization can be in fact instrumental for improving idea integration contributes to the research and practice in this area.

The above distinct effects of perceived value of information (PVI) and perceived value of idea integration (PVII) on communicative and elaborative integration also implies that perceived value of information and perceived value of idea integration which are framed as two sub-constructs of a single theoretical construct, perceived integration efficacy, may be in fact treated as separate constructs.

In other words, perceiving value in others peoples' idea may trigger individuals' tendencies to refer, acknowledge or criticize those ideas but unless individuals perceive value in idea integration, they are not likely to take necessary steps to compliment or fully contradict those ideas by providing reasons of their own or by improving those ideas. It can also be inferred that if individuals believe that idea integration is valuable, they will take the necessary steps to create integrative ideas where they add information to compliment or contradict ideas of others, and this happens at the same rate for ideas that are valued more and those that are valued less. Perceived value of information and perceived value of idea integration thus may be linked to disparate underpinning individual cognitive processes. Although idea integration is an outcome of complex thinking or integrative complexity, the findings of this study, if further corroborated in organizational setting, points us to distinct individual information processing style attributes that may not be well represented in one single construct. The findings of this study therefore have implications for the study of integrative complexity (Gruenfeld 1993).

Examining the effect of prioritization as it pertains to user interface design, we conclude that distinct features can be built into the system for augmenting perceived value of information or perceived value of idea integration. While we did not find any significant difference between the extent to which prioritization influenced either of the constructs, we anticipate that knowing the inherent difference between the two sub-constructs system designers and user interface experts will be able to craft features that most effectively manage each.

At the end, the mixed effect of idea visibility and of prioritization on different types of idea integration is consistent with one of the core principles of this study that more precise measurement of idea integration construct should be developed. This study's perspective on measuring idea integration should be further verified and enhanced. We also believe that measuring different types of idea integration will be a critical part of any future studies of idea integration.

2.12. Conclusion

In this dissertation, we proposed an attention-based view of idea integration in electronic brainstorming and empirically examined the influence of two particular user interface features, namely visibility and prioritization on idea integration. The conceptualized link between user interface and idea integration which is built based on cognitive network model of creativity (Santanen *et al*. 2004) provides the foundation for design of EBS with predictable types of idea integration. The proposed theory provides a basis for user interface customization efforts. The quest for crafting user interfaces that better fit the cognitive requirements of the idea integration provides a new pathway for research and practice on IS interface design. IS interface research has high potentials for supporting cognitively intensive tasks such as electronic brainstorming.

In the laboratory experiments we found that the basic level of idea integration when individuals only refer to each others' ideas, either approving or challenging, without any reason or justification, was higher for higher types of idea visibility. We also found that higher types of idea integration for which more cognitive effort is required increases significantly only when idea visibility is accompanied by diversity of information contained in the ideas. Also, Prioritization effect on idea integration takes different forms for basic types and higher types of idea integration, in that higher perceived value of information leads to an increase in basic level of idea integration and higher perceived value of idea integration leads to an increase in higher types of idea integration.

Since idea integration plays an important role in creativity, this dissertation's findings have implications for the extent to which EBSs, creativity support tools and systems alike expose individuals to the ideas generated in the group. Depending on the level of idea integration which is required for specific purposes, designers may adaptively expose participants to more or less portion of the idea pool. Idea visibility, which was manifested in form of the number of visible ideas on the screen in this dissertation's study, can take other forms. This dissertation's analysis on information diversity suggests that, for example, one could selectively present more diverse ideas (e.g., based on semantic analysis) to mitigate the effect of cognitive load. Future research can be directed to understand how cognitive load and semantic interpretation may interact in idea integration.

With the extensive use of collective content creation platforms within organizations, we provide a set of decision making criteria for managers and group leaders to optimally employ the resources of their knowledge workers. For instance, managers are usually faced with the trade-off between breadth and depth of the ideas that are generated in the groups when exposing individuals to their partners' ideas (Vreede *et al*. 2000). While elaboration and idea integration ensure depth in the discussion, it is desirable that the breadth is also preserved. Insights from this dissertation's proposed theory can inform technology choices to achieve the desired level of depth or breadth. Furthermore, empirical studies based on the theory proposed here and its extension may prove to be insightful to managerial decision making on the choice of technological tools for enhanced idea integration performance.

Undoubtedly there are imitations to generalizability of the findings of this study posed by controlled experiments with participants from student population. For achieving generalizability, the result of this study should be corroborated in organizational settings where competition and other organizational dynamics influence the process and outcomes of brainstorming. An advancement of the current theory could be the identification of user interface attributes other than those discussed here and empirical studies of their effect on ideation integration within groups. Some examples of the attributes are structuring presentations of ideas on the screen (several windows instead of one; e.g., Dennis *et al*. 1996), threading feature, and font size (e.g., digg), or color (McNab 2009).

CHAPTER 3

COMPUTATIONAL STUDY

3.1. Introduction

The findings of the empirical examination of the effect of idea visibility and prioritization on idea integration was partially consistent with the predications of this dissertation's research model as illustrated in Figure 1.1. An unexpected part of the results pertained to the effect of idea integration on the basic level of integration but lack thereof on higher types of idea integration. The lack of a significant association between higher types of idea integration was attributed, at least in part, to the cognitive requirements of higher types of idea integration. Specifically for higher types of idea integration to occurs, individuals exposure to ideas were found to matter only when information contained in the visible ideas was highly diverse. In this chapter I elaborate on the above mixed results concerning the effect of idea visibility from a group composition perspective. Particularly, I propose that parts of the unexpected results from the laboratory experiments described in Chapter 2 may be attributed to difference in group compositions which is fully masked when the effect of visibility and prioritization on idea integration was examined at group level (aggregation of all individuals' integration). It is expected however that group composition which has been left out in the experimental design may influence the dynamics of idea integration. We specifically focus on major group composition aspects that interact with information saliency.

As described in Chapter 1, research has uncovered that electronic brainstorming may suffer from reduced saliency of the ideas and reduced idea integration (Dennis1996). Also, idea integration depends on information saliency but little is known about the interplay between the two and group composition which form the underpinning processes of idea integration. One such process is individuals' attention to the salient ideas which enables idea integration. As described in this dissertation's theory, information saliency in the EBS context which is referred to as exposure to partners' ideas by scholars of group creativity (Zhou & Shalley 2007), is manifested through idea visibility on the user interface. The extent of idea visibility on the screen influences individuals' ability for idea integration in computer-mediated ideation. Moreover, in this chapter I examine the extent to which individual's ability for idea integration may be affected on individual-specific characteristics such as attention and memory retrieval capabilities. Attending to other people's ideas and processing of the information that is contained in them is necessary for idea integration. Attention enables retrieval of relevant information from memory and enables individual to create the conceptual connections different ideas and generate integrative ideas. Thus memory retrieval capabilities are the basis of the study of visibility on idea integration.

Attending to, processing and using information provided by others incurs extra effort to individuals. The extra effort required for integrating other peoples' ideas with those of one's own makes individual's choice an important element for realizing knowledge integration. Therefore, another process involved in idea integration task is individuals' decision making in face of idea integration opportunities. In other words, in addition to exposure to partners' ideas, and attending to those ideas (Dennis1996), individuals must be motivated and make the choice to perform idea integration. As a creative process, idea integration choice is influenced by prior belief on its outcome derived from idea integration experiences (McCardle 1985). Examining idea integration from a data limited vs. resource limited view of processes, attention influences the amount of processing effort allocated to idea integration, and experience influences individuals' perception of the quality of the information contained in partners' ideas and perceptions of possible benefits gained from idea integration (Norman & Bobrow 1975). This dissertation examines the influence of visibility on idea integration contingent on individuals' attention, and individuals' prior experience with idea integration.

This chapter introduces and computationally examines a model of idea integration that formulates the joint influence of (1) idea visibility as an electronic media feature, (2) attention to partners' ideas as a cognitive attribute, and (3) individual's experience with idea integration as a decision-making factor on idea integration in EBS. Idea visibility and attention influence the opportunity for idea integration and individual's experience influences motivation for performing idea integration. From the best of my knowledge, this study is the first that examines the interacting effects of the above three factors on idea integration. Therefore the model created in this chapter provides a theoretical basis for future empirical research. Results from the computational experiments suggest that the influence of idea visibility cannot be expressed in terms of simple effects of either attention or experience. Rather, the effect of visibility on idea integration is moderated by partners' attention-experience disparities.

It is important to note that EBSs may be used for variety of brainstorming forms but consistent with the laboratory experiments, the scope of this study is limited to EBSs used for idea generation where ideas will be exchanged in form of text. And the communication mechanism is limited to via the computer screen. Like in this dissertation's lab experiments, saliency in the current dissertation is operationalized by idea visibility (on the screen). Consistent with this dissertation definition of an idea, idea integration is defined in this chapter by explicit reference and use of the evidence presented in partners' ideas and is closely related to information elaboration, adoption & use (Dennis 1996; Sussman & Siegal 2003; Vreede *et al.*

2003). It is important to note that partners' ideas will also implicitly influence one's ideation by providing cues for probing memory and through activating related concepts in associative memory (Anderson 2005) and by affecting transition among categories (Brown et al. 1998).

Individual's memory retrieval abilities and individual's choice thus contribute to the difference among individuals concerning knowledge integration. Following the attention-based view of the influence of user interface design on knowledge integration, this study examines the influence of visibility on individuals' choice for idea integration by focusing on individuals' memory retrieval capabilities. Accounting for such lower-lever characteristics of individuals in the groups and their choice at each step of the process during group brainstorming was found to be practically impossible to achieve in my laboratory experiments. Therefore this study uses computational modeling as an alternative methodology (Stasser 1980) to examine individual decision making process.

The model developed here compliments the experimental study of the previous chapter in that it takes one step further for explaining the difference among idea integration at group level by examining differences in group composition concerning idea integration. Also this dissertation proposes that visibility of ideas influences knowledge integration via mediating influence of knowledge activation and cognitive load (Figure 1.1) but it does not measure knowledge activation. In the model proposed here knowledge activation is represented and accounted for through activation of evidence that each individual discovers during the idea generation process (Figure 3.1). The evidence as will be defined later in this chapter is the same as idea dimensions of ideas as referred to previous chapters. Also since this dissertation focuses on the influence of user interface features on idea integration, it is imperative to take into account the debate over relevance of individual's cognitive characteristics in system design (Huber 1983, 1992; Rao et al. 1992; Robey 1992). To that end, and to examine the influence of individuals' decision making and memory retrieval capabilities a computational model of individual's ideation that is consistent with the findings of research studies on associative memory retrieval is created. Building upon the attention-based view of idea integration, and assuming that individuals have limited attention capacity the model developed here seeks to examine the influence of visibility on idea integration decision for individuals in the group.

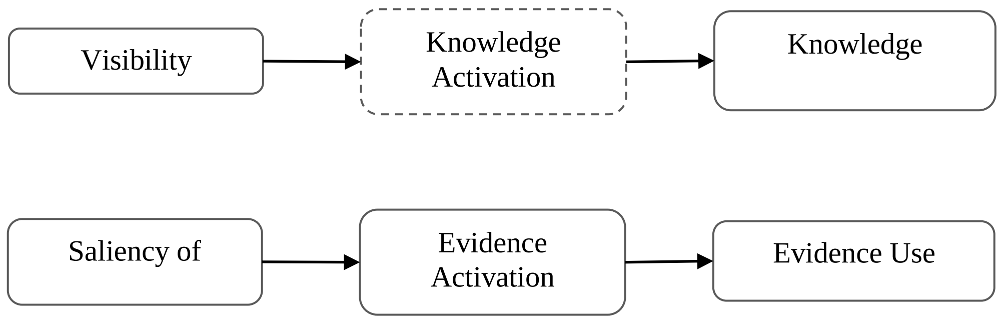


Figure 3.1: Visibility and Knowledge Integration

The computational experiments indicated that in groups with attention disparity, idea visibility has more of an effect on increasing the rate of idea integration, especially when there is experience equality in the group compared to when there is experience disparity. The computational experiments also indicated that, in groups with experience disparity, an increase in idea visibility has a stronger effect on increasing the rate of idea integration when there is attention equality in the group compared to when there is attention disparity. In the computational study report, the rationale for choosing these contingencies and their importance to the study of idea integration in electronic brainstorming groups and the full reports of the results are described.

3.2. Modeling Idea Generation in Groups

In addition to the brainstorming literature, the model developed in this chapter also borrows ideas from research on creativity support tools (Resnick *et al.* 2003). Creativity support tools help individuals express themselves creatively and become creative thinkers. It is presumed that individuals' goal is to be creative thinkers in their organizational context. Therefore software and user interfaces are expected to support users to become more productive and innovative. The focus here is idea integration which is considered the most fruitful process in brainstorming (Osborn 1958).

As described in Chapter 1, idea is defined throughout this dissertation as a basic element of thought that consists of at least one testable proposition (Simon 1947). Each testable proposition contained in an idea is called a dimension. When integrating ideas, individuals may choose to use one or more than one dimension of the ideas that are presented to them. The level of granularity, therefor, in study of integration is dimension not idea. Dimensions in this chapters' computational model are represented by pieces of evidence and ideas are represented by sets of evidence. As such, like dimensions, evidence is at the lowest granularity level in the computational model which is created in this chapter. Particularly, individuals search for and collect evidence and articulate subsets of that evidence and the connection among them as ideas. When evidence contained in the ideas proposed by others is made salient to individuals, they may choose to use those in their ideas. Using a piece of evidence that is contained in the ideas shared by others for the first time is referred to as idea integration. This representation of evidence is similar to that used in previous research studies (Dennis 1996) for representing common and unique facts contained in ideas generated and shared during a brainstorming session on a hidden profile task (Figure 3.2). Unlike pieces of information in hidden profiles which are provided to individuals, pieces of evidence in this chapter's model are discovered and retrieved by each individual during the search in memory (Potter & Balthazard 2004) and are then shared within the group.

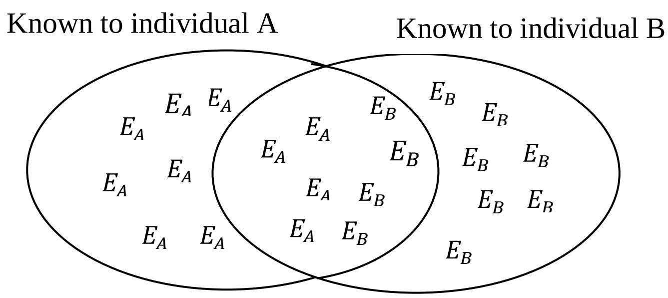


Figure 3.2: Shared and unshared evidence (Dennis 1996)

3.2.1. Individuals' Attention and Experience

Building upon the premise of the importance of visibility or saliency of ideas (Dennis1996), attention (Brown et al. 1998), and motivation (McCardle 1985), this chapter pursues deeper understanding of idea visibility effect on idea integration with respect to attention-experience disparities within groups. Attention disparity means that individuals are different with respect to their attentiveness; and experience disparity means that individuals are different with respect to their experience with idea integration. Similar to performance implications of other within-group disparities such as informational diversity (Homan et al. 2007) attention-experience disparities are shown to influence idea integration as an aggregate group-level measure.

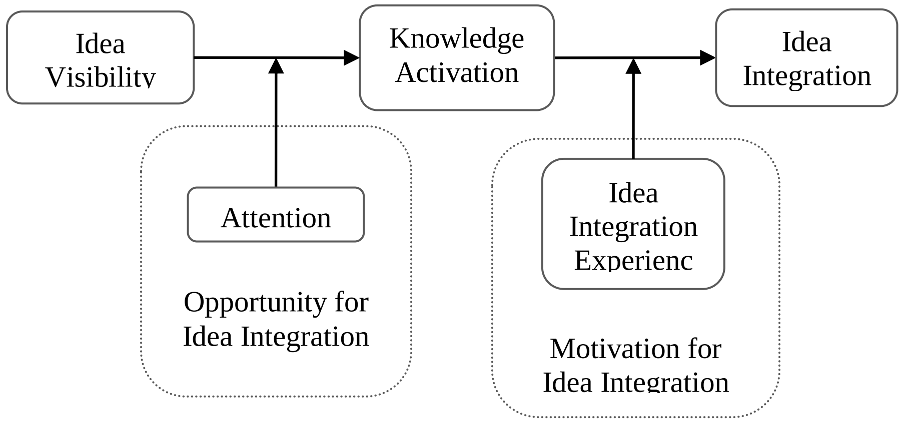


Figure 3.3: A Model of Idea Integration

For idea integration, individuals must perceive different dimensions (differentiation) and be motivated to create the connections among the differentiated dimensions (integration) (Gruenfeld & Hollingshead 1993). An attentive individual will experience more opportunity for idea integration than a less attentive individual (Figure 3.2). Motivation in the study is linked to uncertainty associated with idea integration outcomes (McCardle 1985). Considering that idea integration has a finite set of possible outcomes (e.g., ideas are either *good* or *not good*) and assuming that individuals in the groups are Bayesian decision makers, experienced individuals form a concentrated prior distribution as opposed to a diffuse distribution formed by inexperienced individuals. Consequently, beliefs derived from a concentrated prior distribution for experienced individuals are less uncertain than those derived from a diffuse prior distribution of their inexperienced partners. It is important to note that uncertainty associated with idea integration may also be examined as an exogenous factor linked to partners' ideas' perceived merit and value. This exogenous facet of uncertainty was investigated in the laboratory experiments and was described in Chapter 2 of this dissertation.

This chapter models the impact of idea visibility on idea integration in EBSs, and examines how the impact is contingent on attention to partners' ideas and experience with idea integration (Figure 3.3). The model is a concrete example of confluence of individual's cognitive and behavioral characteristics and IS design (Huber 1992) in studying of EBS performance (Dennis & Valacich 1999; Pinsonnaeult *et al.* 1999). The model is examined by computational experimentation because accounting for the interactive effects of all combinations of individual's characteristics and choices in laboratory experiments is complicated, and often intractable. Although simulation is limited in scope, it provides useful information for understanding the mechanisms involved in particular areas of research studies (Harrison *et al.* 2007; Stasser 1988).

Individual brainstorming processes are building blocks of brainstorming in electronic group. This study proposes that brainstorming in groups is a search (trial and error) process (Potter & Balthazard 2004) that involves searching in evidence space. Brainstorming in electronic groups provide a suitable learning infrastructure for individuals involved in the group brainstorming and the extent to which individuals learn from their previous actions and from each other depends on their learning capabilities.

To accommodate features of search and learning processes (trial and error) this study models search in associative memory by random walk. Random walks are a Markov processes in which states denote position of a walker taking random steps at each time period. Idea generation in groups involves several uncertainties and is influenced by many different individual and group characteristics, representing outcome as a random variable that combines those uncertainties in one variable of interest, provides an integrated method of analysis of the effect of those uncertainties. In this study the target variable is the outcome of ideas integration and based on which individual decides whether to perform integration in the computer-mediated brainstorming. Here the outcome is a simple binary variable indicating whether idea is good or not good.

3.3. Summary of the Model

The model developed in this chapter (Figure 3.4) consists of two sub-layers. The first sub-layer involves the modeling of the search for evidence, and the second sub-layer models idea generation and idea integration. A brief overview of the model follows (see Figure 2):

- Individuals search for evidence.
- Evidence that is collected by individuals is activated based on the frequency and recency of the processes performed on them. Activation is boosted when evidence is visited during the search process or if it is used in idea generation or if it is viewed on the screen. Activation of the evidence via viewing on the screen depends on the saliency that is defined based on the visibility on screen.
- When individual decides to generate an idea, only a subset of evidence that is highly activated, i.e., the activation is greater than a threshold, will be available for idea generation. The subset of evidence with activation above the threshold is called the activation window.
- Some evidence in the activation window have been discovered by partners and have never been used by the individual. Using that subset of evidence in generating ideas is referred to as integration.
- Individuals' experience formed based on the outcome of idea integration in the past plays a role in realizing integration when individuals make decision for idea integration. The idea integration is successful when the created idea is perceived as a good idea; and it failed if the idea is perceived as a bad idea.

In summary, evidence space is intended to represent individuals' background knowledge and the walk in evidence space for collecting evidence is intended to emulate the search in associative memory. Since the space is populated randomly at the start of each trial, the trials correspond to experimental sessions with randomly assigned individuals. Individuals' initial position is also determined randomly from which they navigate the space in search for more evidence. The initial position in the evidence space influences the evidence discovered by the individual during the search process. This influence is consistent with humans' search associative memory in that as a concept is activated in individual's memory, all related concepts will be activated as well. During this spreading activation process, the concepts that are discovered later are dependent on what has been discovered in the past. Each of the above steps will be described in detail in the following sections.

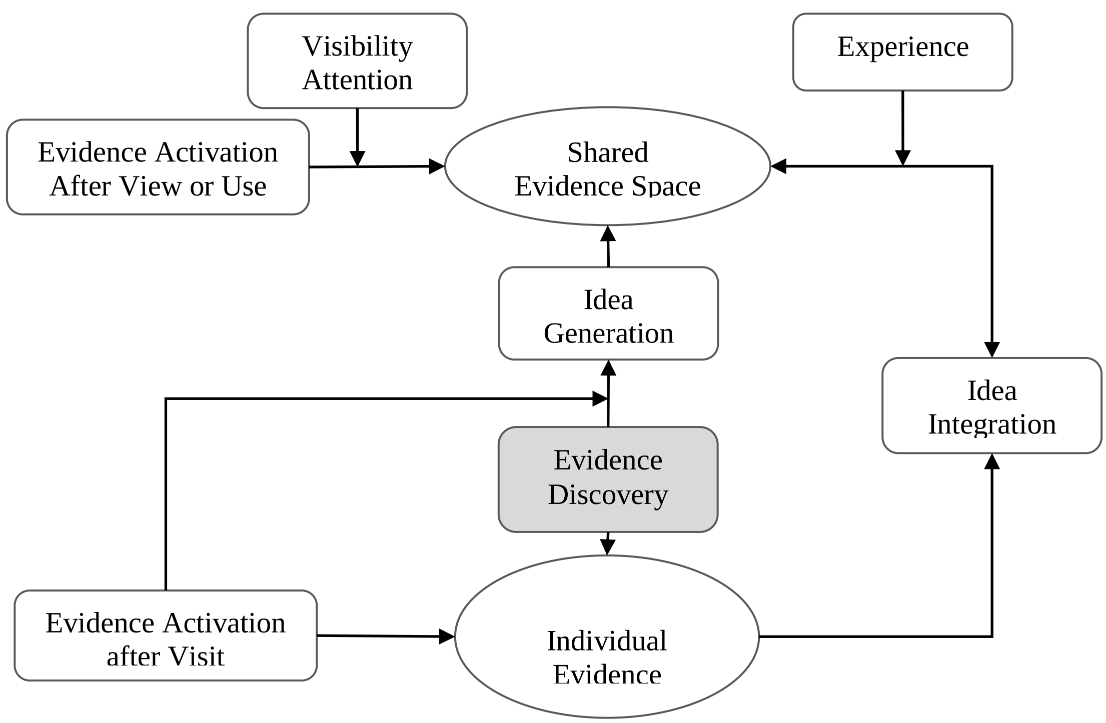


Figure 3.4: Processes and Components of the Model

3.3.1. Search for Evidence

As explained in the first chapter of this dissertation, idea generation can be view as search process. To incorporate that in the computational model of brainstorming, a second layer to represent search in memory is added to the study (Potter & Balthazard 2004). Search in memory during the brainstorming can be viewed as search in the problem space (Boland, et al. 1994). Search in memory in the model is identified as *search in evidence space*. Evidence space is defined as the space in which clues and evidence are distributed and individuals constantly search for new cues in that space (Potter & Balthazard 2004). Search for evidence in the evidence space is modeled by a random walk (e.g., in a two-dimensional space) process with reinforcement learning.

For the sake of tractability, the evidence space is two-dimensional in this chapter study as illustrated in Figure 3.5-3.7. Individuals start at a random point in the space and traverse the space for discovering more evidence which are represented by numbers (1,2,3,…) in Figure 3.5; the numbers indicate the order by which evidence are discovered. When individuals generate and share ideas (represented by circles in Figure 3.5) all the evidence encompassed in those ideas, are automatically shared. The shared pieces of evidence comprise a common space. The shared evidence in the common space are exposed to group's attention subset of evidence can be borrowed and utilized by other individuals for generating new ideas (Figure 3.7).

To allow for informational diversity within groups (Homan et al. 2007), the evidence space is populated randomly at the start of each trial and the initial position in the evidence space is also determined randomly. Without loss of generality, the evidence space here is populated at the beginning of the simulation via a uniform random generator. Evidence space is intended to represent individual's knowledge repository. The structure of individual's knowledge repository then influences availability and saliency of the evidence throughout the brainstorming process. Since individuals usually come to the group with heterogeneous knowledge repository, a random process for shaping the two-dimensional evidence space in the model fairly represents knowledge repositories of individuals within group.

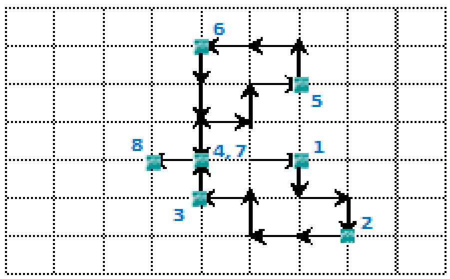


Figure 3.5: Individual's random walk in a 2-dimensional evidence space

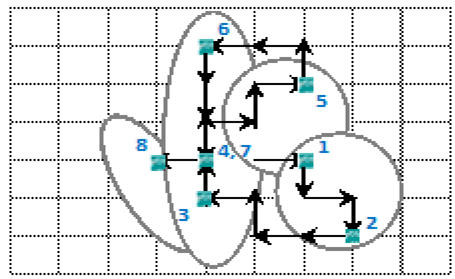


Figure 3.6: Ideas as sets of evidence

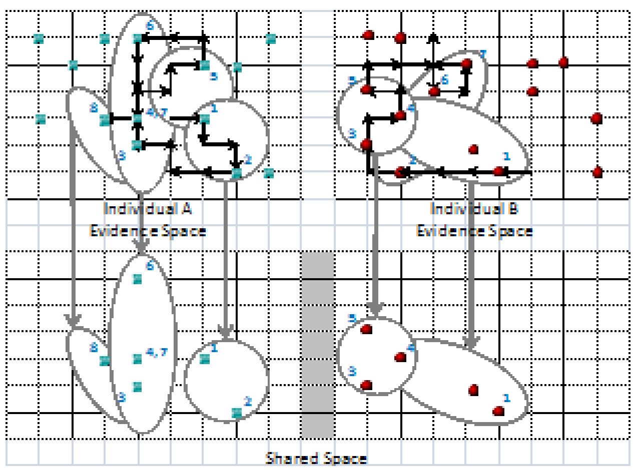


Figure 3.7: Idea sharing leads to the sharing of the evidence

The initial position in the evidence space influences the number of evidence and the order by which they are discovered during the search process (Figure 3.5) (Denrell 2004). This is because the ability of individuals to retrieve new evidence is influenced by the point at which they start searching in their knowledge maps. Individuals' initial position in the evidence space thus influence the number of evidence they are able to collect during the process. This process will consequently bring about difference in individuals performance during the brainstorming process.

Individual's walk in different directions follows a Dirichlet distribution. Dirichlet distribution is the multinomial extension of Beta distribution which is used here for representing a simple Bayesian learning. If evidence is discovered in some direction, individual is more likely to take that direction in the future. In other words, the walk is not symmetric and individual's choice of direction and chance for finding evidence in the future is determined by what directions have been chosen in the past through Bayesian updating of the belief. This asymmetric random walk with reinforcement learning for choosing direction is a simplified representation of the spreading activation of evidences, in which evidences that are discovered are dependent on what has been discovered in the past. As the number of steps of the walk increases, the likelihood of discovering new pieces of evidence decreases. In other words there's a diminishing return on the number of steps. This diminishing return on the number of steps is consistent with the saturating nature of idea generation in groups where the number of ideas increases till some point in time and then stays steady when the upper bound of solution space is approached (Valacich & Dennis 1994).

As soon as subsets of evidence are articulated as ideas and ideas are shared, the visibility of the ideas will play a key role in further activating the evidence; this effect will be explained in the next section.

3.4. Visibility of the Ideas, Evidence Activation, and Idea Generation

As described in the previous section the model developed here maintains that ideas are formed when individuals articulate subsets of evidence and the conceptual connection among them (Figure 3.6). As individuals generate and share ideas, all the evidence encompassed in those ideas are automatically shared. The shared pieces of evidence comprise a common space from which the whole or subset of evidence can be picked and utilized by individuals for generating new ideas (Figure 3.7); individuals can also integrate their own subsets of evidence with those discovered by others and create combinative ideas. Integration means use of evidence that is provided by others and never has been used by own. As soon as the individual uses the evidence for the first time, further use of the same evidence is no longer considered integration. As such in addition to through search new evidence becomes available through the ideas that are shared by others. For the latter group, visibility influences the probability of evidence being used in idea generation.

As specified in this dissertation's model of idea integration (Figure 1), idea visibility and attention influence the ability for idea integration through the mediating effect of knowledge activation. As described in the previous section, the search for cues related to the subject of brainstorming is modeled by the search in the evidence space. In other words, knowledge activation in the model is operationalized by evidence activation (Figure 3.8).

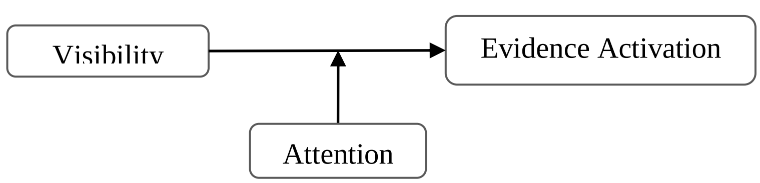


Figure 3.8: Visibility, attention and evidence activation

The role of attention is critical in studying the influence of visibility on idea integration because attention enables information processing that boosts activation and consequently increases individual's ability of knowledge integration.

3.4.1. Evidence Activation

In this study the probability by which evidence will be used is characterized by a measure of activation, which is sensitive to recency and frequency, as in short-term memory. Since ideas are formed when individuals articulate subsets of evidence and the conceptual connections among them, the extent to which a piece of evidence is active influences the likelihood of that evidence being used in the next ideas. This is based on theories of short-term memory (Anderson 2005). Specifically, if the current time is T and the evidence is processed at times $\mathrm{t}_1, \mathrm{t}_2, \dots, \mathrm{t}_\mathrm{n}$, then the activation will be:

$$\text{Evidence Activation} = \sum_{k=1}^{n} (T - t_k)^{-d}$$

Where d is the decay parameter representing the rate by which the evidence is weakened in the individual's memory. As d increases, pieces of evidence processed in previous periods become less active and the probability of them being used in a new idea is diminished. Thus, evidence collected, viewed and used in previous time periods becomes less significant for future idea generations and the probability of the evidence being used in an idea is diminished as time passes.

The activation of evidence for an individual varies based on the operation being conducted on the evidence by the individual. When an individual discovers the evidence, or shares an instance of that evidence in an idea, the activation of that evidence boosts. Also when individual views an instance of the evidence framed in an idea generated by others, the activation is boosted but with different rate. In other words, based on the actions an individual take, the evidence will have different activation level for her/him.

For instance, if evidence E_{A_1} is mentioned by individual A at times $\mathrm{t}_1, \mathrm{t}_2, \dots, \mathrm{t}_\mathrm{k}$, then its activation will be boosted based on its occurrence for individual A. If evidence, $\mathrm{E}_{\mathrm{B}_1}$ is mentioned by individual B at times $t_1, t_2, \ldots, t_l$, evidence E_{B_1}'s activation for individual A will be boosted, but with a discounted rate.. Below is the time period in which each of the evidence has been processed:

$$\hbar istory\ of\ processing\ of\ E_{A1} = \{t_1^{A1}, \ldots, t_k^{A1}\}$$
$$\hbar istory\ of\ processing\ of\ E_{B1} = \{t_1^{B1}, \ldots, t_l^{B1}\}$$

Where $t_1^{A1}, \ldots, t_k^{A1}$are all the times at which evidence E_{A_1} has been visited or used by individual A and $t_1^{B1}, \ldots, t_l^{B1}$ are all times at which evidence E_{B_1} has been viewed by individual A; the activation then will be:

$$\mathrm{act_A(E_A)} = \sum_{i=1}^{k} (\mathrm{T}\text{-}\mathrm{t}_i^{\mathrm{A1}})^{\text{-}\mathrm{d_A}}$$
$$\mathrm{act_A(E_B)} = \sum_{i=1}^{l} \varphi_\mathrm{A} \times (\mathrm{T}\text{-}\mathrm{t}_i^{\mathrm{B1}})^{\text{-}\mathrm{d_A}}$$

Where φ_A is the attention parameter or the discount rate for the decay where evidence processed is only viewed by individual A and is not used. Similarly, if E_{A_1} is shared with individual B, activation of evidence E_{A_1} for individual B will be discounted by φ_B. Now if individual B mentions E_{A_1} again in an idea created by own then E_{A_1} 's activation for individual B will not be discounted. This occurrence, however, will boost activation of E_{A_1} for individual A discounted by φ_A.

Similarly, if E_A is shared with individual B, evidence E_A for individual B will be boosted with a discount. Now if individual B mentions E_A again in an idea created by her/him then E_A will be boosted for individual B by that occurrence, with no discount. This occurrence will boost activation of E_A for individual A with a discount though.

Table 3.1 summarizes the three different processes by which activation of the evidence is boosted: visit, use, and view. The activation varies based on the process type and based on whether the evidence is discovered by own or by others.

Table 3.1: Activation of evidence for individual A

Evidence E	Activation, $act_A(E)$ is boosted by	Activation $act_A(E)$ *T*: Current time *t*: Time of processing
Discovered by B but not shared	-	-
Discovered by B and shared	Viewing	$salinecy \times \varphi \times (T - t_i)^{-d}$
Discovered and shared by B and used by A	Use	$(T - t_i)^{-d}$
Discovered by A but not shared	Visit	$(T - t_i)^{-d}$
Discovered by A and shared	Use	$(T - t_i)^{-d}$
Discovered and shared by A and used by B	Viewing	$salinecy \times \varphi \times (T - t_i)^{-d}$

3.4.1.1. Activation Window

Evidence activation in this chapter's computational model is manifestation of knowledge activation in this dissertation's research model. Based on evidence activation, activation window is defined. At each point of time, activation window includes a subset of pieces of evidence with activation above a threshold assuming that the activation follows the power law formula described above plus a logistic noise and evidence shared by others are activated with a discount. It follows the rules described in Table 1.

$$inclusion\ of\, E_i\ in\ act_W = \begin{cases} 1\ \ if\ activation(E_i) > \tau \\ 0\ if\ activation(E_i) < \tau \end{cases}$$

Where act_W represents activation window and τ is the threshold meaning that evidence with activation above τ maybe included in the idea generated at time t. Pieces of evidence in the activation window are those available for idea generation and inclusion of them in the activation window at time t depends on the activation of that evidence at time *t*.

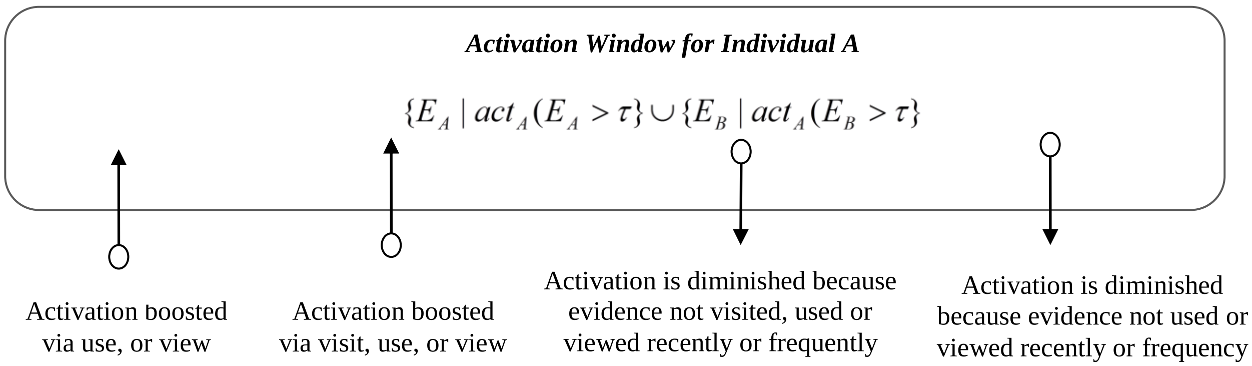


Figure 3.9: Evidence is included in activation window based on their activation

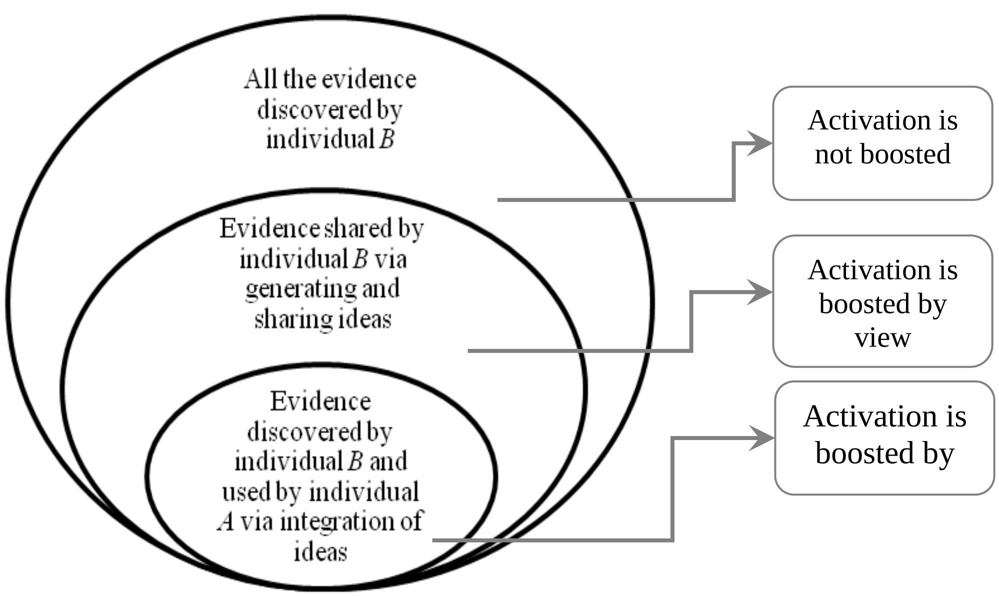


Figure 3.10: Evidence Discovered and Activation

To summarize the process of activation of evidence explained above, Figure 3.10, and 3.11 summarize the three different processes by which activation of the evidence is boosted: visit, use, and view.

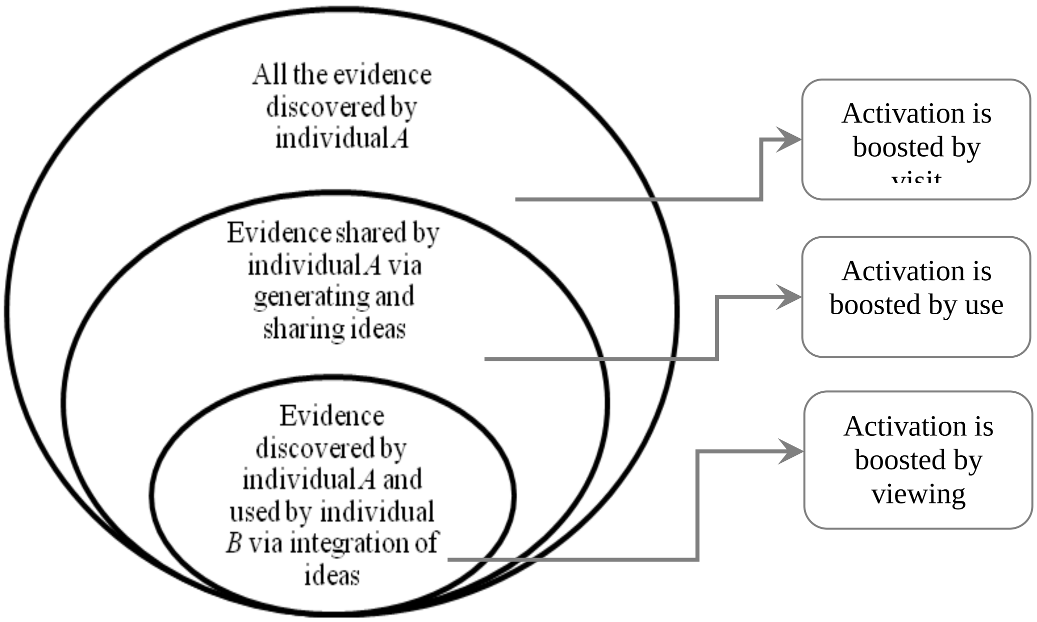


Figure 3.11: Evidence Discovered and Activation

Evidence available in each of those regions may be activated according to the process that is being performed by individual. The activation varies based on the process and based on whether the evidence is discovered by own or by others. Table 3.1 detailed also the formula for the activation of the evidence in each of the above regions for individual A according the owner of the evidence.

When individual decides to generate idea, all the evidence discovered by individual A or B with activation above the threshold will be included in the activation window (Figure 3.11).

Each time any of the processes illustrated in 3.9, and 3.10 is performed, activation is boosted as depicted in Table 3.1. If no process has been done on the evidence, the activation is diminished and the evidence may be no longer included in activation window.

As explained above, some evidence in activation window have been discovered and shared by individual A, and some by individual B. Some discovered and shared by individual B, some have never been used by individual A. Using this subset of evidence leads idea to integration. The summary of processes involved in idea generation and idea integration with respect to use of new and previously discovered evidence by own and newly and previously evidence discovered by others is illustrated in Figure 3.12.

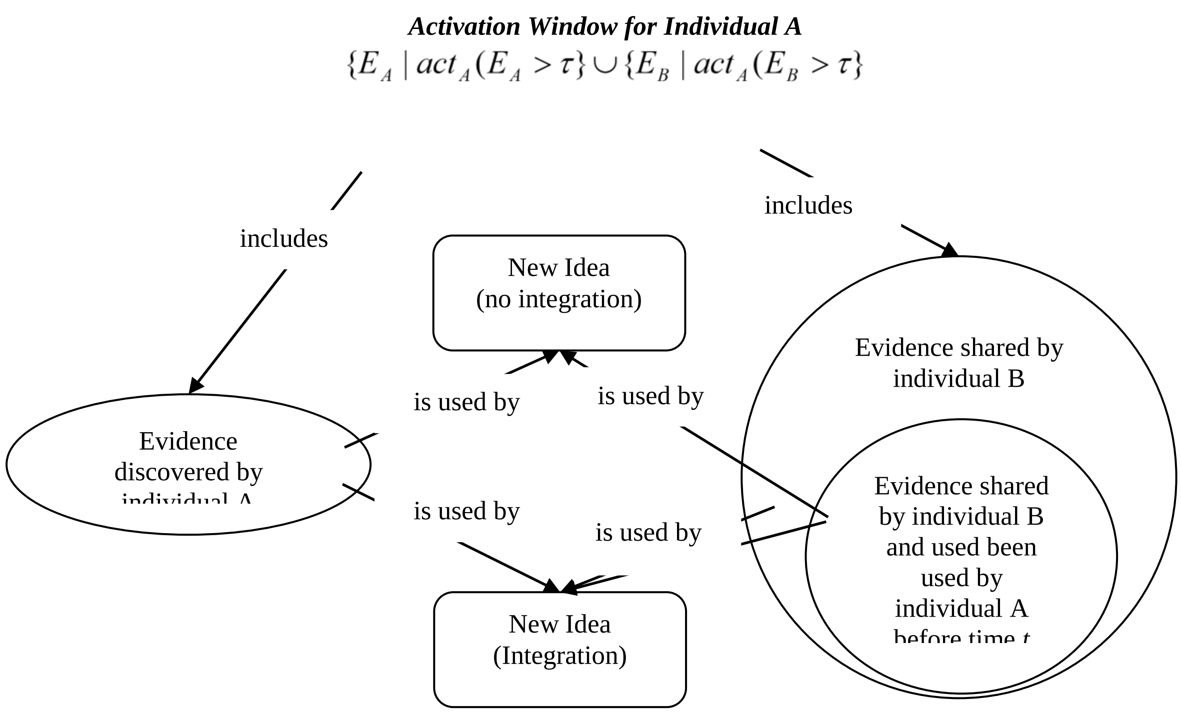


Figure 3.12: Activation window and idea generation

3.5. Individual Experience, Idea Generation Outcomes and Individual Decision Making for Idea Integration

According to this dissertation's theory (Figure 1), an individual's ability for knowledge integration is influenced by visibility and attention Based on motivation-ability framework, individual's ability for knowledge integration is influenced by the visibility of the ideas which influences knowledge activation. This effect has been implemented in the current model as evidence activation. Using the evidence provided by others for the first time is defined as integration. Previous research studies, however, suggests that not all the facts available to the individuals are used by them (Thoemmes & Conway 2007) and sometimes individuals disregard the evidence provided by others. One reason is lack of ability because partners' ideas are not salient and/or not being attended to (Dennis1996). Another reason is lack of motivation because individual may believe that using the evidence provided by partners is not rewarding (Siemsen *et al.* 2007). Idea integration does not always lead to generation of better ideas. In particular, if the value of any piece of evidence is context-dependent, then the quality of the integrated idea depends on what pieces of evidence are combined for creating it (Anderson & Schanteau 1970). In other words, ideas shared by others may provide extra information but they do not necessarily improve quality upon use and integration.

Individual's choice thus contributes to the difference among individuals' performances concerning idea integration. Factors influencing individual's choice for idea integration is expected to similar to those affecting a firm's decision of whether to innovate or not (Mansfield 1968 in McCardle 1985): **(1)** the extent of quality gain from integration compared to not integrating; **(2)** the extent of the uncertainty associated with integration outcome which is contained in the individual's prior distribution of the outcome. A diffuse prior, for instance a Beta with parameters (1, 1), is indicative of greater uncertainty than a concentrated one, such as a Beta with parameters (100, 100) (Mansfield 1968 in (McCardle 1985). In the model, uncertainty is derived from experience with idea integration; and **(3)** the cost associated with integration, which may be defined as the cost of mindfulness (Levinthal & Rerup 2006) and cost of creating conceptual connection among different ideas. While uncertainty associated with idea integration is included in the model, gains from and cost associated with idea integration are left out because of lack of empirical or theoretical research studies for modeling them. The uncertainty associated with idea integration is modeled by a simple Bayesian mechanism for belief updating and decision making which is explained in the next section.

3.5.1. Bayesian Decision Making

To incorporate uncertainty associated with idea integration, the model presented here represents individual's learning from past experience by a Bayesian belief updating process (McCardle 1985). Individual's belief on idea integration's outcome is contained in the prior probability of the idea integration outcome which identifies individual's choice for idea integration. Idea integration can be represented by a biased-coin toss. Idea integration as a creative process inevitably involves an element of chance (Campbell 1960) and may result in failure or success. Success implies that the generated idea is perceived as a good idea, Failure implies that the generated idea is not a good idea. The assumption in this chapter's computational model of electronic brainstorming is that individuals can rate each others' ideas in real time (which is consistent with the practice) and the aggregate subjective evaluations by partners contribute to individual's perception of the success or failure of any particular idea integration instance. The model, however, makes no attempt to characterize the process by which individual's perception is formed based on the other people's feedback and evaluation. The premise is that individuals are capable of forming that belief using mechanisms provided to them by the electronic system. Those mechanisms are used as the best available real-time proxy for ideas' values and may not correspond to the actual quality of ideas. As such, perceived success or failure of idea integration is modeled by a biased-coin toss (Campbell 1960) that allows for individual's Bayesian learning from past experience (McCardle 1985).

When individuals make decisions to integrate their ideas, they evaluate the prospects of those decision based on their belief on the quality of the outcome. When they observe the actual outcome, they update their belief. As individuals continue idea generation and idea integration their estimate of the usefulness of integration is updated in a Bayesian fashion. The first parameter of the Beta distribution of the priors, s, accumulates successful idea integration instances and the second parameter, l, accumulates idea integration failure instances. $s + l$, the sum of the two parameters measures the total amount of information, including those contained in the prior information with those collected in each instance. . Initial beliefs of individuals are stored in the initial parameters. $s + l$, therefore indicates the precision of the resulting estimate. The precision depends on the extent of previous experience (initial parameters) and frequency and outcome of integration at each trial. A second beta distribution stores the information on failure or success of idea generation with no integration. An individual observes the result of generation and based on this result, the belief on the success and the failure of idea integration will be updated in the same fashion as that of idea integration. When individuals generate idea they decide about idea integration based on the idea integration's prospect for success compared to that of idea generation (when no idea integration is performed).

Individual's future decision for integration will be narrowly constrained by what has been gained from integration in the past. As described throughout the dissertation integration requires making the conceptual connection among different prospective thus individual incurs extra effort. Idea integration thus takes effort and is costly. Integration cost as defined here will be similar to that of information acquisition cost defined in previous literature on innovation adoption (McCardle 1985).

In this chapter's computational model, increasing visibility will influence individual's decision to integrate their ideas with those of others via influencing activation of evidence, and individual's choice for integrative activities at earlier stages of collaboration will influence decision choices at later stages through Bayesian belief updating.

3.6. Computational Study

The simulation model was developed using R statistical package. The codes are available in electronic companion to this file. The model was then simulated to examine the effect of visibility on idea integration in groups with different attention- and experience- compositions. The variable parameters are as follow:

Table 3.2: Parameter description and the ranges

Parameter	Description	Range
γ_{ij}	The rate by which individual *i* learns from individual *j*	[0.1,0.5]
β_i	Individual *i* learning by doing rate	[0.5,1.5]
d_i	The rate by which evidence activation is decayed for individual *i*	[0,1]
φ_i	The discount parameter for activation of an evidence presented by other for individual *i*	[0,1]

3.6.1. Setup

Ideas are organized in pages on the screen and each page includes a certain number of ideas. Visibility increases when the number of ideas per page increases. Visibility based on position on screen is a stage function, drops a level when page number increases. Attention is represented by activation decay discount rate for the evidence that is shared by partner (Brown et al. 1998). Inexperience is represented by diffuse priors as in $\beta(1,1)$ and experience is represented by concentrated priors as in $\beta(100,100)$ (McCardle 1985). It is assumed that both individuals are experienced with idea generation in general, meaning that they both have concentrated priors for idea integration. When individuals are given the choice to perform idea integration, they first compare the success prospects for idea generation and integration, and then make the decision based on that comparison. The parameters of the model, their description and their values are depicted in Table 3.3. The ranges of parameters are chosen based on previous literature on reinforcement learning and on associative memory (Anderson 2005).

Table 3.3: Parameter description and their values

Parameter	Description	value
GSize	Group Size	2
Dim1, Dim2	Dimensions of the evidence space	30, 30
Brainstorming duration	Time units spent on brainstorming	1200
Visibility	Number of ideas per page	Low: 5 High: 12
φ_i	Attention	Low: 0.1 High: 0.3
d_i	The rate by which evidence activation is decayed for individual *i*	[0.1-0.5] Set to 0.1, and 0.3

3.6.2. Dependent Variable and Hypotheses

Dependent variable is the total number of idea integration performed by individuals over the total number of ideas generated in the group minus 1. This is because the first idea inevitably is one that does not involve any integration (Vreede *et al.* 2003).

$$Integration\ Ratio\ (IR) = \frac{\sum_{individual\ i's\ in\ group\ g}(\#\ of\ idea\ integration\ by\ individual\ i)}{\sum_{individual\ i's\ in\ group\ g}(\#\ of\ ideas\ generated\ by\ individual\ i) - 1}$$

Dependent variable is normalized. The number of idea integration is divided by the number of ideas because the total number of ideas generated by each group in each trial of the computational experiments varies. The first contingency examined is for groups with attention disparity with two different compositions of experience equality and disparity to examine hypothesis 1:

> ***Hypothesis 1:*** *In groups with attention disparity, visibility has more of an effect on the rate of idea integration increase when there is experience equality in the group than when there is experience disparity.*

The second contingency is for groups with experience disparity with two different compositions of attention equality and attention disparity:

> ***Hypothesis 2:*** *In groups with experience disparity, visibility has more of an effect on the rate of idea integration increase when there is attention equality in the group than when there is attention disparity.*

The rationale for choosing the above three attention-experience contingencies among the four possible contingencies is two-fold. First it is obvious that from Attention Equality-Experience Equality condition to where attention or experience of one individual is higher (lower), there will be a gain (loss) in idea integration because either opportunity or motivation for integration are increased (decreased) (Figure 3.3). Secondly there can be no meaningful comparison of Attention Equality-Experience Equality and Attention Disparity-Experience Disparity (both different) condition because there may exist particular attention-experience disparity conditions (specific values of the parameters) that lead to gain in integration and some other combinations that lead to loss in idea integration. Therefore propositions including Attention Equality-Experience Equality contingency will have little value either because they are obvious or because they cannot be generalized.

Table 3.4: Attention-Experience Contingencies and Hypotheses

Hypothesis	Attention-Experience Contingencies	Independent Variables Values
H1	Attention Disparity-Experience Equality vs. Attention Disparity-Experience Disparity	Attention*: $\varphi_{i=0.3}, \varphi_{j=0.1}$ Prior: $\beta_1(1,1), \beta_2(1,1)$ Attention: $\varphi_{i=0.3}, \varphi_{j=0.1}$ Prior: $\beta_1(100,100), \beta_2(1,1)$
H2	Experience Disparity-Attention Equality vs. Experience Disparity- Attention Disparity	Prior: $\beta_1(100,100), \beta_2(1,1)$ Attention: $\varphi_{i=0.1}, \varphi_{j=0.1}$ Prior: $\beta_1(100,100), \beta_2(1,1)$ Attention: $\varphi_{i=0.3}, \varphi_{j=0.1}$
*φ_i is the attention parameter which represent the rate for which evidence shared by others is attended to by individual *i* and thus is activated. The higher the φ_i the more the ideas of partners are attended to.		

3.6.3. Computation Experiments for Groups

The point estimate of the dependent variable, *IR*, was calculated by its average for 10 simulation runs. The descriptive statistics for the three attention-experience contingencies (second column in Table 3.5) in low and high visibility conditions are shown in Table 3.5.

The output variable *IR* from low visibility to high visibility conditions is collected for each of the three contingencies in 150 runs. The 2-way ANOVA for the factorial design of visibility: [low, high] and attention-experience contingencies: [equal-different, different-equal, different-different] is available in Table 3.6. Also the average IR for binary comparison of the three attention-experience contingencies is included in discussion for each hypothesis.

Table 3.5: Descriptive Statistics for the Total Number of Ideas and Idea Integrations

	Visibility low				**Visibility high**			
		C1*	C2*	C3*		C1	C2	C2
Idea generation	Mean	30.7	29.8	30.6	Mean	32.1	31.7	33.2
	Standard Deviation	20.1	21	16.2	Standard Deviation	20.1	27	25
	Minimum	16	14	18	Minimum	17	13	17
	Maximum	169	168	163	Maximum	173	167	169
Idea Integration	Mean	8.6	28.2	14	Mean	28.6	19.74	21.4
	Standard Deviation	6.8	17.04	7.54	Standard Deviation	20.6	9.31	16.1
	Minimum	2	6	7	Minimum	2	4	3
	Maximum	45	64	31	Maximum	65	75	57

* C1 : Attention Disparity-Experience Equality; C2 : Attention Disparity-Experience Disparity; C3: Experience Disparity-Attention Equality, Count=150

Hypothesis 1: In groups with attention disparity, visibility has more of an effect on the rate of idea integration increase when there is experience equality in the group than when there is experience disparity.

Average IR for [attention disparity – equal experience] increased from 0.07 to 0.19 while it changed from 0.23 to 0.24 [attention disparity – experience disparity]. To interpret the results based on *Hypothesis 1*, it is important to first note that visibility and attention will influence individual's opportunity via influencing evidence activation (Figure 3.3). This implies that the number of times that individuals face the decision for idea integration increases as visibility and attention to partners' ideas increase. In groups with attention disparity thus integration opportunity is lower for the less attentive individual. If less attentiveness is accompanied by less experience, it means that the less attentive individual with will be more sensitive to failure instances of idea integration efforts. Also the more attentive partner who has more experience will face more integration opportunity while being less sensitivity to failure instances of idea integration instances. Over time then, the more attentive partner who has more experience performs more idea integration. This increased idea integration performance in turn decreases the opportunity for the less attentive partner who is also sensitive to failures. Hypothesis 1 suggest that because of this dual-disparity, an increased opportunity for both individuals caused by increased visibility will have less effect when groups with dual disparity compared to groups with attention disparity- experience equality. In other words, the only possible pathway for the less attentive individual to continue idea integration is when partners have comparable (here, equal) experience. With equal experience, instance of idea integration will equally influence partners' motivation for idea integration thus making the influence of visibility much more tangible for the group (Table 3.6).

Table 3.6. 2-Way ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Visibility	0.05	1	0.05	6.52	0.012	3.95
Disparities	0.21	2	0.1	12.37	<0.01	3.1
Interaction	0.12	2	0.06	7.35	<0.01	3.1
Within	0.71	84	0.008			
Total	1.1	89				
Columns contain the data for each of the three contingencies, the attention-equality; experience equality condition was also included in. C1: Attention Disparity-Experience Equality; C2: Attention Disparity-Experience Disparity; C3: Experience Disparity-Attention Equality, Count=90, 15 for each contingency at low and high visibility.						

Hypothesis 2: In groups with experience disparity, visibility has more of an effect on the rate of idea integration increase when there is attention equality in the group than when there is attention disparity.

Average IR for [experience disparity – equal attention] increased from 0.11 to 0.18 while it changed from 0.23 to 0.24 [experience disparity – attention disparity]. To interpret *Hypothesis*

2, it is important to first note that individuals' choices for integration and its outcome at earlier stages of idea generation will influence individual's motivation for idea integration (Figure 3.3) at later stages by influencing decision choices through the Bayesian belief update. That is the number of idea integration efforts, the observed outcomes (failure or success), and the sequence of those outcomes influence individual's motivation for idea integration in future. The motivation, however, is independent from other underpinning processes of activation and depends only on individual's experience and idea integration outcomes and their sequence. For more experienced individuals, failure has less of an effect on motivation for idea integration. In groups with experience disparity, therefore, when a partner is more attentive, increased motivation for idea integration is accompanied by increased opportunity for idea integration (Figure 3.3). This dual advantage leads to an increased number of idea integration for the partners with attention-experience advantage, which in turn decreases opportunity of idea integration for the less experienced partner. This decreased opportunity accompanied by less motivation, causes a decrease in idea integration efforts by the disadvantaged partner. This counterbalancing effect undermines the gain from the increased visibility for the group. In other words, if the level of attention and experience differs, then one partner stays in integration train and the other in the negative loop of not integrating because of either less opportunity or weak belief on idea integration success. These finding from the computational study are also consistent with that of prior research studies in that exposure to others' ideas is not universally beneficial (Potter & Balthazard 2004). The effect illustrated by Hypotheses 1-2 resembles that observed in long leaps in random walk. That is the persistent difference among frequency of the individuals' idea integration may arise even if the outcome of idea integration process is similar to that of a coin toss (Denrell 2004); and this persistence difference in idea integration efforts in groups with dual-disparity significantly reduces the gain from increased visibility.

3.7. Discussion, Conclusion and Summary

The model developed in this chapter connects activation of evidence to the saliency of them. The model is only applicable to the electronic brainstorming because accounting for the visibility of the ideas is made possible by using the position on the screen as the proxy. Ideas visible on the screen are more salient; ideas that are more salient are more likely to be attended to. Attention leads to evidence activation and makes integration more likely to occur.

This computational study builds on theoretical and empirical research on electronic brainstorming and creativity. The goal is to explain variance among the idea integration in groups in the same experimental condition in the empirical study of Chapter 2. It thus enriches this dissertation's theory of idea integration which was laid out in Chapter 2. Group composition is expected to play a role in any group-wide process (Robert *et al.* 2007). This chapter introduced and computationally examined two important aspects of group composition which influence idea integration, namely experience with idea integration and attentiveness to ideas of others. The computational experiment presented in this dissertation suggested that tweaking visibility may not play a significant role in groups with both attention- and experience- disparities. The findings also suggest that in groups with attention or experience disparity only, increased visibility leads to increased idea integration. In other words, groups with dual disparity may not gain much from greater exposure to each others' ideas and groups with attention or experience disparity only, will gain much from greater exposure to each others' ideas during the brainstorming process. An implication of the study for group designer and facilitator is that when idea integration is a crucial performance indicator, groups with people who have different attention skills and experience may not warrant an optimal composition. Attention skills may be inferred from individual's previous activities in terms of attending to ideas and information shared by others. Experience may also be inferred from the extent to which an individual have been able to effectively use ideas of others and combine them to create better ideas in the context of organizational problem solving or other related activities (e.g., in Rich 1979).

The computational study conducted in this chapter provides a theoretical foundation based on which further laboratory experiments can be designed in which attention and experience parameters and other parameters of model may be estimated. Such laboratory experiments will complement the empirical study laid out in this dissertation. The rationale for choosing computation experiments in the current study was based on unavailability of theories to guide design and build of such laboratory experiments. It is important to note that task- and context- specific factors have not been included in this study. For instance, groups with similar group compositions may behave differently when working on different tasks, or using different communication modes, or when social structure or anonymity is altered. Thus the study poses some limitation in that regard.

The current model may be modified in any of the following ways. (1) Assumptions: evidence space may be characterized differently, and the Dirichlet-based random-walk in the evidence space may be replaced by more precise representation of spreading activation. Such representation may include the distance in the evidence space as a proxy for the extent of association among concepts. The predictions of the model are expected to be robust with respect to the above alteration since the current assumptions are consistent with theories that this study is built upon. (2) Independent and dependent variables: other user interface features such as font size and color (McNab 2009), cognitive factors such as learning by doing, and learning from others (Siemsen et al. 2007), and other forms of belief updating models such as those of believers in law of small numbers and outcome autocorrelations (Barberis & Vishny 1998; Rabin 2002) may be part of future endeavors to further enlighten this area of research. Also other dependent variables such as timing of idea integration may be examined for more precise predictions of effect of the interacting effect of user interface features, and cognitive and behavioral factors. Apart from the above incremental improvements, future extension of this work may include combining explicit and implicit idea integration, characterizing the cost of mindfulness or being attentive and the cost for idea integration (Levinthal, & Rerup 2006; Simon 1976).

Being aware of the limitation of the study with respect to validation, I believe this study is a starting point for more comprehensive approaches to IS design which takes into account cognitive and behavioral factors. The conceptualized link between idea visibility and the two dimensions of group composition, attention and experience, provides a foundation for tailoring the extent of exposure to others' ideas based on the extent of attention- and experience-disparities among group members. The quest for finding a better fit between user interface features and the cognitive and decision-making dimensions of the group composition provides a new pathway for research and practice on IS artifact design for cognitively intensive tasks in general and electronic brainstorming in particular (Rao *et al.* 1992). The study of information saliency effect on idea integration in EBS is also consequential for creativity research because electronic media is the prevalent platform for exchanging ideas.

CHAPTER 4

SUMMARY AND CONCLUSION

This chapter concludes with discussing the implications of this dissertation's developed framework and the conducted empirical and computational studies for idea integration, electronic brainstorming, and IS user interface.

This dissertation created a framework that links IS user interface design to the creation of firm's knowledge-based capabilities through facilitating idea integration at the group level. The framework focuses on visibility and prioritization as two interface attributes that enable and motivate individuals to integrate ideas at the group level. Integration of individuals' ideas or combinative capabilities (Kogut & Zander 1992) is indispensable for creating firms' knowledge-based capabilities. Since knowledge integration is realized by integrating the knowledge that resides within individuals at the group level (Grant 1996a; Okhuysen & Eisenhardt 2002), this dissertation contributes to organizational knowledge creation by focusing on idea integration within groups. The focus on idea integration is based on the assumption that individuals' specialized knowledge will provide no value to the firm unless the knowledge is processed, integrated and used. As such unless shared ideas are integrated and used by recipients, idea generation and idea sharing provide no benefits to the group (Grant 1996b).

Building a theory of user interface that considers firms as knowledge integrating institutions is important because computer-mediated collaborative knowledge creation is the prevalent platform for group brainstorming within firms (McAfee 2006). Since user interface is the point of contact to the shared knowledge base, its attributes will significantly influence the extent of knowledge integration in groups. Thus, user interface can be instrumental in deploying interventions, which enhance individuals' abilities and motivations for knowledge integration.

In the laboratory experiments we found that the basic level of idea integration when individuals only refer to each others' ideas, either approving or challenging, without any reason or justification, was higher for higher types of idea visibility. We also found that higher types of idea integration for which more cognitive effort is required increases significantly only when idea visibility is accompanied by diversity of information contained in the ideas. Also, Prioritization effect on idea integration takes different forms for basic types and higher types of idea integration, in that higher perceived value of information leads to an increase in basic level of idea integration and higher perceived value of idea integration leads to an increase in higher types of idea integration.

The computational study conducted in this dissertation also provides a theoretical foundation based on which further laboratory experiments can be designed in which attention and experience parameters and other parameters of model may be estimated. Such laboratory experiments will complement the empirical study laid out in this dissertation. The rationale for choosing computation experiments in the current study was based on unavailability of theories to guide design and build of such laboratory experiments. It is important to note that task- and context- specific factors have not been included in this study. For instance, groups with similar group compositions may behave differently when working on different tasks, or using different communication modes, or when social structure or anonymity is altered. Thus the study poses some limitation in that regard.

User interface also plays a key role in finding new patterns of productivity for electronic brainstorming systems. The theory developed here and the empirical study therefore contributes to the resolution of the debate over the *illusion of productivity* of electronic brainstorming (Pinsonneault *et al.* 1999). The proposition of the *illusion of productivity* of electronic brainstorming (Pinsonneault *et al.* 1999) in part stems from the fact that paying attention to other individuals' ideas and processing them -which is expected to contribute to idea integration-, interferes with idea generation and adversely influence brainstorming productivity. To alleviate the distraction caused by others' input and to maximize the benefits of group brainstorming manipulation of idea visibility proposed in this study can be instrumental.

For enabling the firm as a knowledge-integrating institution, IS researchers need to actively pursue theoretical and empirical research that contributes to knowledge integration and the attention-based theory developed here allows for systematic study of user interface effect on knowledge integration. The attention-based theory of user interface design is constructed based on the fundamental logic of Simon (1947) for bounded rationality that stems from individuals' limited capacity for attention. As described in previous chapters, the framework developed here is currently being examined through a series of laboratory experiments in which visibility and prioritization are manipulated for their effect on variations in knowledge integration. The empirical study conducted in this dissertation also allowed for further examination of interface design attributes effect on knowledge integration within groups.

This dissertation suggests use IS user interface design feature for enhancing knowledge integration in electronic groups. Building upon electronic brainstorming literature (Dennis *et al.* 1996), it extends the use of interface attributes for enhancing productivity through promoting knowledge integration. Building an attention-based view of the influence of user interface on knowledge integration contributes the design of interfaces that are better fit for the task of knowledge integration. As computer-mediated collaborative knowledge creation is the prevalent platform for group ideation within firms (McAfee 2006) and since user interface is the point of contact to the shared knowledge base, its attributes will significantly influence the extent of knowledge integration in groups and the fit between the user interface features and the task is enhanced by closer look at the cognitive requirements of the knowledge integration and cognitive characteristics of the users.

Building upon Simon's (1947) logic for attention as a scarce resource in organizations, this dissertation links IS interface attributes to the creation of firm's knowledge-based capabilities in the era of extensive use of collaboration technologies (McAfee 2006). It creates the foundation for further empirical studies that contribute to managerial decision making for deploying technologies, which improves knowledge integration and use. Assuming that no one individual has sufficient knowledge to generate the best idea, knowledge integration becomes a key to realizing more fully the value of the individually generated ideas. The current dissertation proposes that knowledge sharing and integration are different processes with different antecedents and different consequences (Okhuysen & Eisenhardt 2002) that calls for further investigation for the influence of user interface attributes on knowledge integration.

Consistent with Ocasio's (1997) attention based view for describing organizational moves by intentional processes shaped by individuals, organizations, and the environment, this dissertation develops a theory of IT user interface for directing attention at the group level for increased knowledge integration. The *move* in this dissertation is defined at the group level by the extent to which individuals build upon each others' ideas and therefore generate interactively complex ideas. This dissertation's definition of idea visibility is similar to that of availability and saliency of issues and answers in Ocasio's (1997) attention-based theory. Ocasio also suggests that individuals are selective in the items they attend to and what they do (here generating, sharing, integrating ideas) will depend on what they focus their attention on. In this dissertation, selectiveness manifests itself in prioritization where preferences of individuals is represented through rating of ideas and that prioritization based on the aggregate ratings of individuals are proposed to stimulate more integration when integration is the desirable action.

Attention-based view of the firm also suggests that from all issues and answers, decisions makers are more likely to consider and to attend those with greater value, legitimacy, and relevance to the organization. This dissertation posits that to enable firm as knowledge integrating institution, knowledge integration at group level must be valued and be facilitated through use of effective IT interface features for it to become a regulating force in channeling individuals' attention. To persuade integrative behavior (or action), the discussion connects to that of the *Rule of the game* in Ocasio's dissertation and rules in this dissertation can be easily implemented via IT features; for instance as part of structuring attention in laboratory experiments explained in Chapter 2 individuals are rewarded not only for generating ideas and sharing them but also for integrating the ideas.

Viewing firm as a knowledge-integrating institution (Grant 1996a) and considering that knowledge integration occurs at group level and that user interface can be instrumental in enhancing knowledge integration in electronically-enabled environment, this dissertation has implications for intention-based view of the firm when the desired *move* is knowledge integration in groups. As a result most premises of the attention-based view manifest in the attention-based view of the user interface design for enhanced knowledge integration and the theory developed in this dissertation is a derivative of the Ocasio's attention-based view in the realm of Information Systems.

Since idea integration plays an important role in creativity, this dissertation's findings have implications for the extent to which EBSs, creativity support tools and systems alike expose individuals to the ideas generated in the group. Depending on the level of idea integration which is required for specific purposes, designers may adaptively expose participants to more or less portion of the idea pool. Idea visibility, which was manifested in form of the number of visible ideas on the screen in this dissertation's study, can take other forms. This dissertation's analysis on information diversity suggests that, for example, one could selectively present more diverse ideas (e.g., based on semantic analysis) to mitigate the effect of cognitive load. Future research can be directed to understand how cognitive load and semantic interpretation may interact in idea integration.

Also, state-of-the art technologies have created many new channels of information and knowledge generation and sharing. Because of the abundance of information made available via use of these technologies, many of the ideas and knowledge will be never used as they are not exposed to viewers' attention. Storing the rarely used ideas along with repetitions of the same ideas leads to information waste. Although information waste management has received little attention in IS research, it has critical implications for knowledge management efficiency and effectiveness. It is proposed that the best method for controlling information waste is to lower the speed of production (Schwolow 2009) and this study proposes that enhanced knowledge integration and use is a key process for alleviating the information waste problem.

Examining knowledge integration in electronic groups using this dissertation's developed framework contributes to the resolution of the paradox of group ideation. As knowledge integration distinguishes group outcomes from those individuals and effective design of user interface for enhanced knowledge integration distinguishes outcome of electronic groups from that in face-to-face setting, a key *pattern of productivity* (Dennis & Valacich 1999) for electronic brainstorming is discovered here. The findings of this study and future empirical study thus contribute to resolving the debate in research and practice over the effectiveness of electronic brainstorming. Researchers are able to identify user interface features for creating new *patterns of productivity* for electronic brainstorming groups; and by drawing attention to knowledge integration and enabling manger's choice for user interface features electronic ideation outcome will be more likely to surpass that of individual and face-to-face ideation.

REFERENCES

Anderson, J. R. (1983). The Architecture of Cognition. Harvard University Press, Cambridge, MA.

Anderson, J. R. (2005). Cognitive Psychology and its Implications (6th ed.), W.H. Freeman, New York, NY.

Anderson, J. R. & Lebiere, C. (1998). The Atomic Components of Thought. Erlbaum, Mahwah, NJ.

Anderson, N. H. & Shanteau, J. C. (1970). Information integration and risky decision making. Journal of Experimental Psychology, 84(3): 441-451.

Baker-Brown, G., Ballard, E. J., Bluck, S., deVries, B., Suedfeld, P. & Tetlock, P. (1992). The integrative complexity coding manual. In C. Smith (Ed.), Handbook of Thematic Analysis, (pp. 605-611). Cambridge University Press, Cambridge, UK.

Barberis N, Shleifer A, Vishny R. (1998). A model of investor sentiment. Journal of Financial Economics 49(3): 307-343.

Briggs, R.O. (2006). On Theory Driven Design and Deployment of Collaboration Systems. *International Journal of Human-Computer Studies*, 64(7): 573-582.

Barkhi, R. (1995). An Empirical Study of the Impact of Proximity, Leader and Incentives on Negotiation Process and Outcomes in a Group Decision Support Setting, Doctoral dissertation, The Ohio State University, Columbus, OH.

Boland R. J., Tenkasi R. V., & Teeni, D. (1994). Designing information technology to support distributed cognition. *Organization Science,* 5(3): 456-475.

Borgatti, S. P. & Cross, R. (2003). A relational view of information seeking and learning in social networks. *Management Science*, 49(4): 432-445.

Briggs, RO. (1995). The focus theory of group productivity and its application. *Journal of Management Information Systems*, 12 (3): 155-170.

Brown, V., Tumeo, M., Larey, T. S., & Paulus, P. B. (1998). Modeling cognitive interactions during group brainstorming. *Small Group Research*, 29(4): 495-526.

Campbell, D.T. (1960). Blind Variation and Selective Retentions in Creative Thought as in Other Knowledge Processes, *Psychological Review*, 67(6): 380-400

Davidson, G S, Dornburg, CC, Stevens, SM & Forsythe, JC (2007). *Yellow Sticky, PHP Software for an Electronic Brainstorming Experiment* [Sandia Report 2007-5702]. Sandia National Laboratories, Albuquerque, NM.

Dennis, A. R. (1996). Information exchange and use in group decision making: You can lead a group to information, but you can't make it think. *MIS Quarterly*, 20(4): 433-457.

Dennis, A. R., Valacich, J. S., Connolly, T. & Wynne, B. E. (1996), Process structuring in electronic brainstorming, *Information Systems Research*, 7(2): 268-277.

Dennis, A. R., & Valacich, J. S. (1999). Research note, Electronic brainstorming: Illusions and patterns of productivity. *Information Systems Research*, 10(4): 375-377.

Dennis, A. R. & Wixom, B. H. (2001). Investigating the moderators of the group support systems use with meta-analysis. *Journal of Management Information Systems*, 18(3): 235-257.

Dennis, A.R., B.H. Wixom, & R.J. Vandenberg (2001). Understanding Fit and Appropriation Affects in Group Support Systems via Meta-Analysis. *MIS Quarterly*, 25(2): 167-193.

Denrell, J. (2004). Random walks and sustained competitive advantage. *Management Science*, 50(7): 922-934.

Desanctis G., Gallupe R. B. (1987). A Foundation for the Study of Group Decision Support Systems, *Management Science,* 33(5): 589-609.

Driver, M.J. & S. Streufert, S. (1969). Integrative Complexity Approach to Individuals as Information-Processing Systems. *Administrative Science Quarterly*, 14(2): 272-285.

Dyer, W. G. (1987). *Team Building: Issues and Alternatives* (2nd ed.). Addison-Wesley, Reading, MA.

Eckhoff, P. Holmes, C., Law, P. Connolly, M. & and Gold, J. I. (2008). On diffusion processes with variable drift rates as models for decision making during learning, *New Journal of Physics*, 10 (1).

Edwards, J.R., & R.P. Bagozzi (2000). On the Nature and Direction of Relationships between Constructs and Measures. *Psychological Methods*, 5, 155-174.

Ferran, C. & Watts, S. (2008). Videoconferencing in the Field: A Heuristic Processing Model, *Management Science*, 54(9): 1565-1578.

Fornell, C., & Larcker, D. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, 18(1), 39-50

Fjermestad, J., & S.R. Hiltz, (1999). An Assessment of Group Support Systems Experimental Research: Methodology and Results. *Journal of Management Information Systems,* 15(3): 7-149.

Fjermestad, J., & S.R. Hiltz (2001). A Descriptive Evaluation of Group Support Systems Case and Field Studies, *Journal of Management Information Systems*, 17(3): 115-159.

Gallupe R. B., Dennis A.R. , Cooper W. H., Valacich J. S., Bastianutti L. M., Nunamaker J.F. (1992). Electronic brainstorming and group size. *Academy of Management Journal* 35(2): 350-369.

Gawronski, B. & Bodenhausen, G. V. (2005). Accessibility effects on implicit social cognition: The role of knowledge activation and retrieval experiences. *Journal of Personality and Social Psychology*, 89(5): 672-685.

Gefen, D., & Straub, D. (2005). A Practical Guide to Factorial Validity Using PLS-Graph: Tutorial and Annotated Example. *Communications of the Association for Information Systems*, 16, 91-109.

Gefen, D., Straub, D., & Boudreau, M.-C. (2000). Structural Equation Modeling and Regression: Guidelines for Research Practice. *Communications of the Association for Information Systems*, 4 (7): 1-70.

Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology*, 78 (6): 1360-1380.

Grant, R. M. (1996a). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17 (Special issue): 109-122.

Grant, R. M. (1996b). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science*, 7(4): 375-387.

Gruenfeld, D. H., & Hollingshead, A. B. (1993). Sociocognition in work groups – The evolution of group integrative complexity and its relations to task-performance. *Small Group Research*, 24(3): 383-405.

Gruenfeld, D. H., Mannix, E. A., Williams, K. Y., & Neale, M. A. (1996). Group composition and decision making: How member familiarity and information distribution affect process and performance. *Organizational Behavior and Human Decision Processes*, 67(1): 1-15.

Guilford, J.P. (1956). The structure of intellect, *Psychological Bulletin*, 53(4): 267-293.

Hair, J., Anderson, R., & Tatham, R. (1987). Multivariate Data Analysis. New York, NY: Macmillan.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, 44(1): 82-111.

Hansen, M. T., & Haas, M. R. (2001). Competing for attention in knowledge markets: Electronic document dissemination in a management consulting company. *Administrative Science Quarterly*, 46(1): 1-28.

Harrison, D.A. & K.J. Klein (2007). What's the difference? Diversity constructs as separation, variety, or disparity in organizations. *Academy of Management Review*, 32(4): 1199-1228.

Harrison, J. R., Lin, Z., Carroll, G. R., & Carley, K. M. (2007). Simulation modeling in organizational and management research. *Academy of Management Review*, 32(4): 1229-1245.

Harvey, O. J.Hunt, D. E. & Schroder, H. M. (1961). *Conceptual Systems and Personality Organization.* John Wiley & Sons, New York, NY.

Hollingshead, A. B. (1996). The rank-order effect in group decision making. *Organizational Behavior and Human Decision Processes*, 68(3): 181-193.

Homan, A. C., van Knippenberg, D., Van Kleef, G. A., & De Dreu, C. K. W. (2007). Bridging faultines by valuing diversity: Diversity beliefs, information elaboration, and performance in diverse work groups. *Journal of Applied Psychology*, 92(5): 1189-1199.

Huber, G. P. (1983). Cognitive-style as a basis for MIS and DSS design- Much ado about nothing. *Management Science*, 29(5): 567-579.

Huber, G. P. (1992). How to deal with cognitive-style-response, *MIS Quarterly*, 16(2): 153-154.

Johnson, D. W. & Johnson, F. P. (1982). *Joining Together: Group Theory and Group Skills* (2nd Ed.). Englewood Cliffs, NJ: Prentice Hall.

Katz, N., Lazer, D., Arrow, H., & Contractor, N. (2004). Network theory and small groups. *Small Group Research*, 35(3): 307-332.

Katz, N., Lazer, D., Arrow, H., & Contractor, N. S. (2005). Applying a network perspective to small groups: Theory and research. In M. S. Poole & A. B. Hollingshead (Eds.), *Theories of Small Groups: An Interdisciplinary Perspective,* Sage, Newbury Park, CA.

Kock, N. (2009). WarpPLS 1.0 User Manual. ScriptWarp Systems, Laredo Texas. Retrieved online June 7, 2010 from http://www.scriptwarp.com/warppls/UserManual.pdf.

Kogut, B., Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science* 3(3): 383-397.

Krackhardt, D. (1992). The strength of strong ties: The importance of philos in organizations, in *Organizations and Networks: Structure. Form, and Action*, N. Nohria and R. Eccles (Eds.), Harvard Business School Press, Boston, 216-239.

Landauer, T.K. & Dumais, S. (1997). A solution to Plato's problem: The latent semantic analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, 104 (2): 211-240.

Landauer, T.K., Foltz, P. & Laham, D. (1998). Introduction to latent semantic analysis. *Discthese Processes*, 25 (2): 259-284.

Levinthal, D. & Rerup, C. (2006). Crossing an apparent chasm: Bridging mindful and less-mindful perspectives on organizational learning. Organization Science, 17(4): 502-513.

Litchfield R. C. (2008). Brainstorming reconsidered: A goal-based view. *Academy of Management Review*, 33 (3): 649-668.

Madjar, N. & Shalley, C. E. (2008). Multiple tasks and multiple goals effect on creativity: Forced incubation or just a distraction? *Journal of Management*, 34, 786-805.

Mansfield, E. (1968). *The Economics of Technological Change*. W. W. Norton and Company, New York, NY.

March, J. G. & Simon, H. A. (1958). *Organization*. John Wiley & Sons, New York, NY.

McAfee, A. P. (2006). Enterprise 2.0, The Dawn of Emergent Collaboration, *MIT Sloan Management Review*, 47(3): 20-29.

McCardle, K. F. (1985). Informatino Acquisition and the Adoption of New Technology, *Management Science*, 31(11): 1372-1389.

McNab, A. L. (2009). Designing Interfaces for Faster Information Processing: Examination of the Effectiveness of Using Multiple Information Cues, *Proceedings of fifteenth Americas Conference on Information Systems*, San Francisco, CA.

Mitchell V.L. (2006). Knowledge integration and information technology project performance, *Mis Quarterly* 30(4): 919-939.

Nahapiet, J. & Ghoshal, S. 1998. Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review*, 23(2): 242-266.

Nonaka I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1): 14-37.

Norman, D.A. and Bobrow, D.G. (1975). On data-limited and resource limited processes. Cognitive Psychology, 7:44-64.

Ocasio, W. (1997). Towards an attention-based view of the firm. *Strategic Management Journal*, 18 (Special issue): 187-206.

Okhuysen, G. A. & Eisenhardt, K. M. (2002). Integrating knowledge in groups: How formal interventions enable flexibility. *Organization Science*, 13(4): 370-386.

Osborn, A. F. (1953). Applied Imagination; Principles and Procedures of Creative Thinking, Scribner, New York, NY.

Patnayakuni, R., C.P. Ruppel, & A. Rai (2006). Managing the complementarity of knowledge integration and process formalization for systems development performance. *Journal of the Association for Information Systems*, 7(8): 545-567.

Petty, R.E. and Cacioppo, J.T. (1986). *Communication and Persuasion*, Springer-Verlag, New

York, NY.

Phillips, K. W., Mannix, E. A., Neale, M. A., & Gruenfeld, D. H. 2004. Diverse groups and information sharing: The effects of congruent ties. *Journal of Experimental Social Psychology*, 40(4): 497-510.

Pinsonneault, A., Barki, H., Gallupe, R. B., & Hoppen, N. (1999). Electronic brainstorming: The illusion of productivity. *Information Systems Research*, 10(2): 110-133.

Potter, R. E. & Balthazard, P. A. (2002). Virtual team interaction styles: Assessment and effects. *International Journal of Human-Computer Studies*, 56(4): 423-443.

Potter, R. E. & Balthazard, P. (2004). The role of individual memory and attention processes during electronic brainstorming. *MIS Quarterly*, 28(4): 621-643.

Raaijmakers, J. G. W. & Shiffrin, R. M. (1981). Search of associative memory. *Psychological Review*, 88: 93-134.

Rao, H. R., Jacob, V. S. & Lin, F. (1992). Hempispheric-specialization, cognitive differences, and their implications for the design of decision support systems. *MIS Quarterly*, 16(2): 145-151.

Reinig, B.A., R.O. Briggs, & J.F. Nunamaker (2007). On the Measurement of Ideation Quality. *Journal of Management Information Systems*, 23(4): 143-161.

Rich, E. (1979). User Modeling via Stereotypes, *Cognitive Science*, 3: 329-354.

Robert, L.P., & A.R. Dennis. (2005). The Paradox of Richness: A Cognitive Model of Media Choice.

IEEE Trans. Professional Comm., 48(1): 10–21.

Robert, L. P., Dennis, A. R., & Ahuja, M. K. (2008). Social capital and knowledge integration in digitally enabled teams. *Information Systems Research*, 19(3): 314-334.

Robey, D. (1992). More ado about cognitive-style and DSS design- Response. *MIS Quarterly*, 16(2): 151-153.

Rousseau, D. (1985). Issues of level in organization research: Multi-level and cross-level perspectives. In L. L. Cummings & B. Staw, *Research in Organizational Behavior,* 7: 1–37, Greenwich, CT: JAI Press.

Rulke, D. L. & Galaskiewicz, J. (2000). Distribution of knowledge, group network structure, and group performance. *Management Science*, 46(5): 612-625.

Santanen, E. L., Briggs, R. O., & De Vreede, G. J. (2004). Causal relationships in creative problem solving: Comparing facilitation interventions for ideation, *Journal of Management Information Systems*, 20(4): 167-197.

Shalley, C. E. & Perry-Smith, J.E. (2008). The emergence of team creative cognition: The role of diverse outside ties, socio-cognitive network centrality, and team evolution. *Strategic Entrepreneurship Journal*, 1 (2): 23-41.

Shepherd, M. M., R. O. Briggs, B. A., Reinig, J. Yen, & J.F. Nunamaker (1996). Social Comparison to Improve Electronic Brainstorming: Beyond Anonymity. *Journal of Management Information Systems*, 12(3): 155-170.

Sheppard, S. & Rouff, C. (1994) in Marciniak (Ed.) *Encyclopedia of Software Engineering*, John Wiley & Sons, New York, NY.

Shiv, B. & Fedorikhin, A. (1999). Heart and mind in conflict: The interplay of affect and cognition in consumer decision making. *Journal of Consumer Research,* 26 (3): 278-292.

Shiv, B. and Fedorikhin, A. (2002), "Spontaneous versus controlled influences of stimulus-based affect on choice behavior. *Organizational Behavior and Human Decision Processes*, 87 (2): 342-370.

Siemsen, E., Balasubramanian, S, & Roth, A. V. (2007). Incentives that induce task-related effort, helping, and knowledge sharing in workgroups. *Management Science*, 53(10): 1533-1550.

Simon, H.A. (1947/1976*). Administrative Behavior: A Study of Decision-making Processes in Administrative Organization*, Macmillan Co, New York, NY.

Smith, P.L., & Ratcliff, R. (2004). Psychology and neurobiology of simple decisions, *Trends in Neuroscience*, 27: 161-168.

Sparrow, R. T., Liden, R. C., Wayne, S. J. & Kraimer, M. L. (2001). Social networks and the performance of individuals and groups. *Academy of Management Journal*, 44(2): 316-325.

Strasser, G. (1988). Computer simulation as research tool- The discussion model of group decision-making, *Journal of Experimental Social Psychology*, 24(5): 393-422.

Straub, D., Boudreau, M.-C., & Gefen, D. (2004). Validation Guidelines for IS Positivist Research. *Communications of the Association for Information Systems*, 13, 380-427.

Streufert, S. & Swezey, R.W. (1986). *Complexity, Managers, and Organizations,* Academic Press, Orlando, FL.

Suedfeld, P., Tetlock, P. E., & Streufert, S. (1992). Conceptual/integrative complexity. In C. P. Smith (ed.), *Motivation and Personality: Handbook of Thematic Content Analysis* (pp. 393-400).Cambridge University Press, Cambridge, MA.

Sussman, S.W. & W.S. Siega (2003). Informational influence in organizations: An integrated approach to knowledge adoption. *Information Systems Research*, 14(1): 47-65.

Thomas-Hunt, M. C., Ogden, T. Y., & Neale, M. A. (2003). Who's really sharing? Effects of social and expert status on knowledge exchange within groups. *Management Science*, 49(4): 464-477.

Thoemmes, F. J. & Conway, L. G. (2007). Integrative complexity of 41 US presidents, *Political Psychology*, 28(2): 193-226.

Valacich JS, Dennis AR, Connolly T. (1994). Idea Generation in Computer-Based Groups – A new ending to an old story. *Organizational Behavior and Human Decision Processes,* 57(3): 448-467.

Valacich, J. S. & Dennis, A. R. (1994). A mathematical model of performance of computer-mediated groups during idea generation, *Journal of Management Information Systems*, 11(1): 59-72.

van Knippenberg, D., De Dreu, C. K. W., & Homan, A. C. (2004). Work group diversity and group performance: An integrative model and research agenda. *Journal of Applied Psychology*, 89(6): 1008-1022.

Vreede, G.J. de, R.O. Briggs, R. van Duin, & B. Enserink (2000). *Athletics in Electronic Brainstorming: Asynchronous Electronic Brainstorming in Very Large Groups* in: J.F. Nunamaker, & R.H. Sprague, (Eds.). Proceedings of the 33rd Hawaiian International Conference on Systems Sciences, IEEE Computer Society Press.

Vreede, G.J. de, R.O. Briggs & R. Reiter-Palmon (2010). Exploring Asynchronous Brainstorming in Large Groups: A Field Comparison of Serial and Parallel *Subgroups. Human Factors*, 52(2): 189-202.

Vreede, G.J. de, & Dickson, G. (2000). Using GSS to design organizational processes and information systems: An action research study on collaborative business engineering. *Group Decision and Negotiation*, 9(2): 161-183.

Vreede, G. J. de, Davison, R. M., & Briggs, R. O. (2003). How a Silver Bullet May Lose its Shine. *Communications of the ACM*, 46(8): 96-101.

Wasko, M. M. & Faraj, S. (2005). Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS Quarterly*, 29(1): 35-57.

Woolley, A. W., Gerbasi, M. E., Chabris, C. F., Kosslyn, S. M., & Hackman, J. R. (2008). Bringing in the experts - How team composition and collaborative planning jointly shape analytic effectiveness. *Small Group Research*, 39(3): 352-371.

Zhang, W. & S.A. Watts (2008). Capitalizing on Content: Information Adoption in Two Online Communities. *Journal of the Association for Information Systems*, 9(2): 73-94.

Zhou, J, & C. Shalley (2007). *Handbook of Organizational Creativity*, Lawrence Erlbaum Associates Inc, US.

APPENDIX A: CONSTRUCTS' MEASUREMENT

Integrative Complexity Measure (Baker-Brown et al. 1992)

Score of 1: no integration

There is no sign of either conceptual differentiation or integration at this scoring level. The proposer relies, without qualification, on a simple, one-dimensional rule for interpreting

Score of 2

In a statement assigned a score of 2, the proposer recognizes the potential for looking at the same issue in different ways or along different dimensions. Differentiation however is emerging, but is not fully developed.

Score of 3

A statement with a score 3 includes clear specification of at least two distinct ways of dealing with the same issue. The proposer recognizes that these different perspectives or dimensions can be held in mind simultaneously. The proposer may also specify conditions under which these perspectives or dimensions are applicable. However, there is no evidence of conceptual integration. Differentiation is the key element of a score of 3.

Thus far, the explanation of the scoring technique has focused on various ways of delineating types and indicators of differentiation.

Score of 4

In a score of 4, we seek signs of the emergence of the second major scoring element, integration. That is, we begin to find indication of the ability to integrate different and sometime conflicting alternatives. Conceptual integration is not clearly apparent at this level, however. Instead, the integration of alternatives is implicit.

Score of 5

A score of 5 indicates the explicit expression of integration. Score 4 may be viewed as the transition point between and expression solely by differentiation and one where evidence of integration appears. Whereas a score of 4 signifies the emergence of integration expressed in a tentative or uncertain manner, a score of 5 indicates that integration is clearly evident.

Score of 6

A score of 6 involves a high-level of interaction; at this level alternatives are readily accepted, compared or contrasted, and integrated so as to presents at least one outcome. There must be an explicitly presented global view with only an implicit indication of the specific dynamics of alternative.

Score of 7:

The unique characteristic of a score of 7 is the presence of an overarching principle or perspective pertaining to the nature of the relationship or connectedness between alternatives. In a score of 7, alternatives are clearly delineated and are described in reasonable detail.

Baker-Brown (Baker-Brown *et al.* 1992) measurement of idea integration is modified in two aspects. First, unlike Baker-Brown, this dissertation emphasizes integration of individuals' idea with those of others. Therefore at least one dimension or perspective referred to in scoring should be of another individual's idea.

Also, in this dissertation, if the stated information is as described in score 1 and 2, it is not counted as integration; therefore the measurement will employ scores 3-7 assuming that when quality of the integration is measured differentiation has already occurred. So scores 1-2 do not apply. Scores 3-7 are recoded to 1-5 to represent different types of integration.

Visibility

Visibility is defined by the portion of the idea pool that is visible without extra effort. Therefore, it is the number of ideas that are placed on the screen and are visible without scrolling or changing pages. This construct is manipulated this by changing the size of the idea pool presented to the members via the interface. The purpose is to create three types of visibility: low, medium and high.

Prioritization

Prioritization is rank ordering of ideas based on the collective evaluation by individuals in the group. As ideas are posted individual in the group can rate them and the aggregate of all the ratings the idea receive identifies its rank. Ideas then are posted on the screen according to their rank. Those who receive higher rating will be then up in the list and therefore much more visible.

Perceived Integration Efficacy

Perceived integration efficacy is defined by perception of the individuals on how integration contributes to the quality of the outcome which is the ideas generated by the group. This constructs has two dimensions; the belief of individuals on the value of the ideas chosen for integration, *perceived value of integration* which is very similar to *perceived information credibility* used by Dennis (1996); individuals' belief on the extent to which integration adds value to the ideas generated by individual: perceived value of knowledge integration. This construct will be measured by a self-report questionnaire. Items used for measuring perceived integration efficacy will be similar to that used in measuring perceived knowledge sharing efficacy.

Diversity of the Ideas

LSA is a statistical technique that measures the conceptual similarity of two texts on the basis of a higher dimensions space with a few hundred dimensions (Landauer & Dumais, 1997). Latent semantic analysis (LSA) is used to measure diversity of the ideas. Latent semantic analysis has been proved valid in measuring similarity in meaning of texts and its scores are consistent with that of human judgment (Landauer, Foltz & Laham 1998). LSA uses the number of times different words occur in a text and use aggregate statistics of all words to compute similarity in meaning of texts to each other (Landauer *et al.* 1998). Tools provided by Landauer *et al.* (http://lsa.colorado.edu) are used. The aforementioned LSA tools receive texts and return a number in [-1, 1] which represents similarity/difference among the two passages.

An important distinction between this dissertation's measurement of information diversity and those of previous studies (Homan *et al.* 2007; Robert *et al.* 2008) is that previous studies measure diversity by accounting for references to the pieces of information on the case that have been asymmetrically distributed among the group members. The measurement however is task-independent for which measuring diversity does not rely on any specific experimental procedure with regard to distribution of case-related information.

Group Size

Group size is the number of individuals participating in an ideation session. Group size in the previous experimental studies of Group Support Systems (GSS) has ranged from 2 to 18 (e.g., Dennis *et al.* 1996; Gallupe 1992; Santanen *et al.* 20044). Dennis & Wixom (2001) referred to groups with five or fewer members as small and groups with six or more members as large. Based on the previous studies, this dissertation refers to groups of five or six (Rulke & Galaskiewicz 2000) members as small and ten to twelve members as large.

Heart and Mind Scale (Shiv & Fedorikhin 1999)

When deciding whether to complete the idea generation task, I was driven by:

My feelings My thoughts

1 2 3 4 5 6 7

My willpower My desire

1 2 3 4 5 6 7

My prudent self My impulsive self

1 2 3 4 5 6 7

The emotional side of me The rational side of me

1 2 3 4 5 6 7

My head My heart

1 2 3 4 5 6 7

Mood Scale (Shiv & Fedorikhin 2002)

At this moment, how are you feeling?

Good bad

1 2 3 4 5 6 7

Unpleasant pleasant

1 2 3 4 5 6 7

Happy Sad

1 2 3 4 5 6 7

Negative Positive

1 2 3 4 5 6 7

Covariates

How would you rate your level of knowledge about deserts?

Very little Very much

1 2 3 4 5 6 7

How would you rate your level of interest in generating ideas on a challenging topic?

Very little Very much

1 2 3 4 5 6 7

How often do you think about dealing with hypothetical situation that you might find yourself in?

Not at all Very often

1 2 3 4 5 6 7

How would you describe your level of interest in deserts?

Very little Very much

1 2 3 4 5 6 7

Are you a native English speaker?

Yes No

APPENDIX B: INSTRUCTIONS TO PARTICIPANTS

Instructions, Page 1

General Instructions

Welcome and thank you for participating in this experiment. This is an experiment on idea generation and discussion in groups. You will be part of a group discussing a survival problem. A hypothetical situation will be explained to you and you will be asked to generate ideas on items you, as a group, wish to have to survive in that situation.

You have 10 minutes to read the instructions and ask any questions from the experimenter to make sure all the parts of the instructions are clear and you know how the system works.

Please note that as explained in the consent form, all participants who complete the experiment will receive course credit regardless of the performance in the group. The payment will be made after the experiment.

Drawing

To motivate your active participation in the discussion and idea generation, the member in the group with the most useful list of items at the end of the discussion will be entered into a drawing for $100 Barnes and Nobel gift certificate.

The usefulness of generated ideas will be evaluated by experts. The participant in each group, with the ideas evaluated as the best, will be recognized in or around 8 weeks from the date of the experiment.

The winner participant in each group then will enter the drawing with a chance proportionate to twice the score accumulated in the discussion.

Therefore the more active you are in the group discussion and the better your final list of items, the higher is your chance of winning the $100 gift certificate.

You may leave the experiment at any time if you wish to stop participating.
Thank you again.

Instruction, Page 2

Surviving in Desert

In this experiment you are discussing and generating ideas on what items you as a group wish take in order to survive in the desert.

The Situation

It is approximately 10:00 A.M. in mid August and you have just crash landed in the Sonora Desert in southwestern United States. The light twin engine plane, containing the bodies of the pilot and the co-pilot, has completely burned. Only the air frame remains. None of the rest of you has been injured.

The pilot was unable to notify anyone of your position before the crash. However, he had indicated before impact that you were 70 miles south-southwest from a mining camp which is the nearest known habitation, and that you were approximately 65 miles off the course that was filed in your VFR Flight Plan.

The immediate area is quite flat and, except for occasional barrel and saguaro cacti, appears to be rather barren. The last weather report indicated the temperature would reach 110 that day, which means that the temperature at ground level will be 130. You are dressed in light weight clothing-short sleeved shirts, pants, socks and street shoes. Everyone has a handkerchief. Collectively, your pockets contain $2.83 in change, $85.00 in bills, a pack of cigarettes, and a ballpoint pen.

What Items will help you survive?

Your task is to come up with as many useful items as possible that, in addition to those you have already, you wish to take so as to survive in the above situation. The rules are:
(a) The items should be portable.
(b) You should explain why the selected items are important for surviving in this situation.

You may assume:
1- The number of survivors is the same as the number of individuals on your group.
2-You are the actual people in the situation.
3-The team has agreed to stick together.
4- Your suggested items are in good conditions.

Instruction, Page 3

Your Score

During the group discussion, you receive points for different actions that you perform. These points are accumulated and reflected in an individual score. This score indicates how active you are in the group and it shows the extent to which you contribute to the discussion. You will receive **<u>5</u>** points for the following actions:

1. Posting new ideas, i.e.:

- Suggesting a new item: for every new item that you suggest, you should give the reason why it is important to your survival
- Suggesting a new use or a new/additional reason for an item that has already been suggested by other members of the group for other uses.
- Posting counterarguments to ideas posted by others if you don't agree with them as long as you explain why you don't agree.

<u>More info:</u> You are also encouraged to post your follow up questions related to the ideas posted by others but be sure to clarify what idea you are referring to.

2. Evaluating ideas posted by others: rating the items that are suggested by others according to their importance for your survival as a team

<u>More info:</u> During the discussion you are encouraged to rate the ideas posted by other.
You can rate posts as they come on your screen. You will also be able to rate them later during the discussion.
List of the posts by others that you have not rated yet will appear on right side of your screen. You can click on them, read them, and rate them.
Please note that you <u>DO NOT</u> have to evaluate all the posts by others.
But you will receive 5 points any time you rate an idea posted by another member.

3. Referring to ideas posted by others and using them in your discussions

If your ideas on items and their importance relate to or make use of another group members' ideas, refer to the original idea in your postings.
<u>More info:</u> As each of you has different ideas on how to use different items for your survival, you are encouraged to pay attention to the ideas posted by others.
You may choose to refer to the ideas posted by others and combine your ideas with those of others <u>if that HELPS YOU CREATE BETTER IDEAS.</u>
To keep track of the ideas you like to incorporate in your discussion, you can mark them for future reference as you browse the posts.
But you will receive 5 points any time you refer to an idea posted by other.

Instructions, Page 4

Starting Discussion and Idea Generation in Group

The discussion starts after this. You are expected to make contributions, share your ideas with other members of your group, pay attention to ideas posted by others, and refer to them as necessary or combine them with your own ideas if that helps you create better ideas.

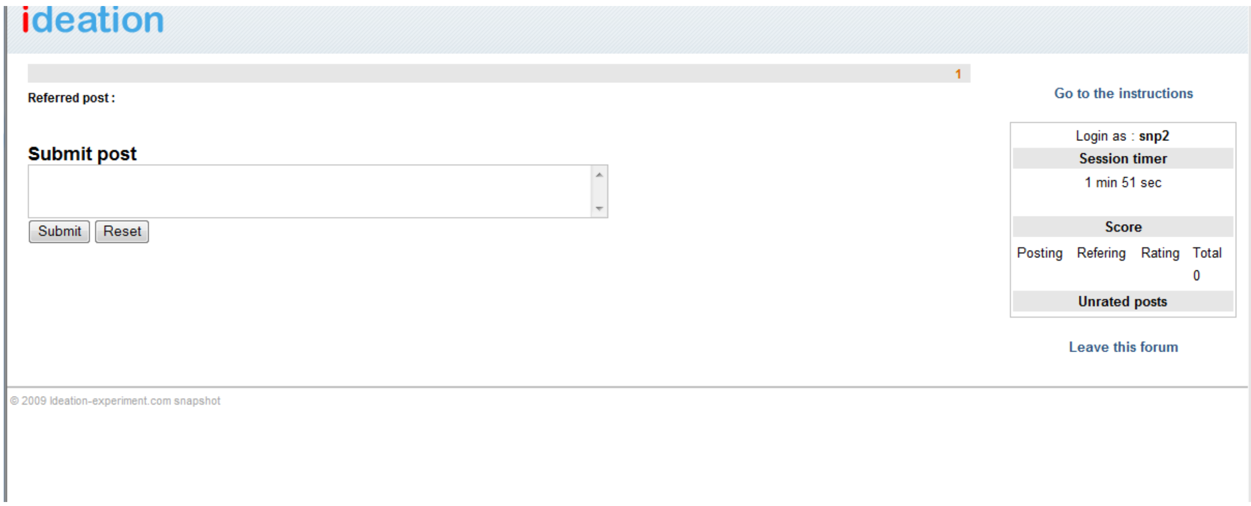
Orders by Which Posts Are Seen on the Screen
The system works similarly to weblogs where you can discuss a topic and comment on other peoples' posts. It is not necessary though that you be familiar with how weblogs work.
The posts are presented on screen as they come in. Only limited number of posts can be seen on the screen; you can always navigate back and forth in the pool of posts by clicking on the page number button on the bottom of the list.

Duration
You will have:
1. 25 minutes to generate ideas on and discuss the items you wish to take.
2. 10 minutes to select 5 items from the list of all the items suggested by the group according to your personal view of how important it would be in helping you survive. Your list may include items that you suggested or the items that other group members suggested.

The Winner Idea
The list of items you have selected will be evaluated by an expert. The individual with the best list -the most important items along with the reason why (s)he has chosen them- will be the winner. The winner's score then will be doubled:
*New score=score gained in the game*2*
Then the winner will enter a drawing for $100 Barnes and Noble gift certificate with a chance proportionate to the new score.
For example, if your score at the end of the discussion is 60 and your list is the winning list, your new score will be 60*2=120
And you enter the drawing for $100 Barnes and Noble gift certificate with a chance proportionate to 120/ total scores of all the winners across all the experimental sessions we are running.

Thank you again for your participation.

APPENDIX C: SYSTEM SNAPSHOT



APPENDIX D: SAMPLE TRANSCRIPT

Session ID: S1

Design code: (1)

# of posts on the screen: 3

Prioritization: NO

# of participants: 2, 1 non-native, 1 native English speaker

Color code:

New item/ new use

Referrals (integration)

Repetitions

No	Time	Posted by	Post texts
1	19:28:59 pm	p2	water is necessary as everyone needs water to survive.
2	19:29:02 pm	p1	a knife to cut plants and forage for food
3	19:29:57 pm	p1	a large water tank with a spigot dispenser
4	19:30:23 pm	p2	food such as bread is necessary to make sure everyone will have enough strength to walk through the dessert.
5	19:30:52 pm	p1	a large piece of white linen to wrap around ythe head to away from the sun
6	19:31:53 pm	p2	I think we can use knife to protect us from wild animals, too.
7	19:32:02 pm	p1	a walking stick
8	19:32:32 pm	p2	compass will be useful for use to locate the correct direction
9	19:33:13 pm	p1	sun goggles to protect the eyes
10	19:33:42 pm	p1	hiking boots to navigate the desert terrain
11	19:33:50 pm	p2	But i think the walking stick is a little heavy to carry
12	19:35:12 pm	p1	walking stick not to carry on your back but to help you walk through the desert. Its going to be an exhausting 70 mile walk
13	19:35:46 pm	p1	2 weeks provisions, basic food stuffs
14	19:36:10 pm	p2	GPS can probably help the group to get better information about the direction
15	19:36:30 pm	p1	white linen to wrap around the body to prevent sun burns and to soak up

			sweat **5**
16	19:37:00 pm	p1	Definitely a GPS **14**
17	19:38:05 pm	p1	a portable tent so you could sleep in
18	19:38:53 pm	p1	if gps has no signal for some reason or is against the rules at least a compass
19	19:39:15 pm	p1	a map of the terrain
20	19:39:18 pm	p2	As the dessert is so hot, it will be so important to have something to protect us.
21	19:40:04 pm	p1	maybe a white article of light clothing to prevent sunburn and loss of water. Especially head protection **5**
22	19:41:30 pm	p2	Sun goggles is necessary to have as the sunlight will damage the eyes **9**
23	19:41:32 pm	p1	A general desert survival information book that shows how to survive under these cases of being stranded and also shows where to find food
24	19:42:13 pm	p1	a box of medical supplies to treat any wounds
25	19:42:57 pm	p2	It is probably better to use the map, compass and GPS together. **8,14,19**
26	19:43:38 pm	p1	A watch to keep time and pace, and to estimate distance traveled. and determine when to sleep and wake up
27	19:44:02 pm	p2	It will be so important to have basic medical supplies. **24**
28	19:44:39 pm	p1	true, gps is probably gonna be on my top list
29	19:46:15 pm	p1	toilet dissertation because there is nothing to wipe with in the desert
30	19:46:44 pm	p2	The tent may protect us from the attack of wild animals.
31	19:46:57 pm	p1	flint and a box of tinder to start a fire. Important to cook and ward away desert coyotes during the night
32	19:47:46 pm	p2	yes, i agree. A compass will be a better device to carry as the GPS may lose signals or out of power. **8,14,19,25**
33	19:48:58 pm	p1	a radio transmitter to call for help or listen for information
34	19:49:02 pm	p2	definitely a good idea to have a map of that dessert, it will at least make the group to find the approximate location and direction
35	19:50:12 pm	p2	i do not think a watch will be necessary as we can observe the weather condition around us. And we can only take 5 items with us
36	19:50:33 pm	p1	dried meat and fresh fruits
37	19:51:05 pm	p2	light stick or lighter to help use get some fire during the nights.
38	19:51:36 pm	p1	a satellite phone to call for help
39	19:52:04 pm	p2	but toilet dissertation is not very urgent, we are in an emergence right now
40	19:53:13 pm	p2	those things will be the most desirable thing for me in the dessert
41	19:53:46 pm	p2	we need to bring extra battery
42	19:54:22 pm	p1	yes, possibly a solar charger

APPENDIX E: SAMPLE IDEAS

To help clarify this dissertation's definitions of idea, dimensions, and idea integration, examples from experimental sessions are illustrated in Table below.

Table E.1: Examples of Ideas Exchanged during the Experimental Sessions with their Type

Description	Idea
One-dimensional idea	*I think some sort of tarp would be useful for shade and shelter.* *First-aid kit to ensure some security against any injury that may occur. Usually contain an abundance of supplies that can be used for several occurrences*
Multi-dimensional idea	*some sort of outer shell jacket that is water proof, can be used to collect water if it rains, covers body at night* *We also need to worry about poisonous snakes, maybe we should bring a snake book so we can identify which ones are poisonous and which ones we can eat.*
Creative idea	*How about a rope? we can take a part of the plane and tie it. Take turns pulling each other. Rest of us will sit down and rest.*
Infeasible idea (<u>not</u> counted as an idea)	*Maybe we can have some workers get shipped in too and they can do the physical labor.*
A referral that is <u>not</u> counted as an integration	*I agree, i think shoes would be better* *Since it is quite a long journey and desert temperatures in the night quite cold. I can understand the point of bringing wood and dry leaves*
Counter argument	*I think that in order to survive, a knife will definitely be needed to hunt for food.* *the land is barren, i do not believe there are any animals* *If we can reach signals, then how about cell phone. we can call for help.* *No, cell phone signals come from towers. There wouldn't be any towers nearby i don't think.*
Improvement	*How about a torch? to help us during the night as its gonna be pitch dark in the desert* *would a flashlight be better? although the battery may run out, we wouldn't need anything to light it.*
One additional reason	*Water- a human body cannot go a long time without water* *that is a good idea, we will not have to carry as much water*
Counter argument + alternative idea	*since it gets very cold at night, we may need blankets* *blankets would just create more bulk, the jacket has more practical usage*
More than one additional reason	*Do you think that energy bars are better or something like dried fruit?* *Yeah, energy bars is also a good idea, also it is more convenient to carry and can be distributed amongst us in an equal proportion.*

APPENDIX F: SAMPLE LSA CODING

Table F.1: LSA Coding for an Experimental Transcript

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1		0.66	0.67	0.72	0.7	0.67	0.69	0.51	0.76	0.79	0.6	0.81	0.73	0.69	0.69	0.77	0.7	0.66	0.76	0.66	0.69	0.68	0.78
2	0.66		0.7	0.73	0.84	0.75	0.67	0.82	0.73	0.84	0.63	0.74	0.74	0.76	0.72	0.84	0.87	0.85	0.75	0.87	0.77	0.69	0.72
3	0.67	0.7		0.76	0.72	0.71	0.61	0.59	0.69	0.78	0.58	0.66	0.7	0.68	0.66	0.74	0.6	0.69	0.68	0.67	0.64	0.67	0.65
4	0.72	0.73	0.76		0.72	0.79	0.77	0.61	0.8	0.88	0.71	0.77	0.85	0.76	0.83	0.85	0.7	0.75	0.82	0.73	0.79	0.83	0.77
5	0.7	0.84	0.72	0.72		0.71	0.7	0.6	0.77	0.84	0.65	0.77	0.72	0.85	0.67	0.84	0.72	0.82	0.76	0.68	0.72	0.71	0.76
6	0.67	0.75	0.71	0.79	0.71		0.77	0.6	0.86	0.88	0.71	0.8	0.84	0.84	0.8	0.86	0.76	0.77	0.88	0.76	0.84	0.83	0.8
7	0.69	0.67	0.61	0.77	0.7	0.77		0.52	0.83	0.82	0.78	0.8	0.81	0.79	0.71	0.8	0.73	0.7	0.8	0.67	0.77	0.76	0.78
8	0.51	0.82	0.59	0.61	0.6	0.6	0.52		0.54	0.66	0.49	0.57	0.58	0.52	0.55	0.62	0.83	0.61	0.59	0.84	0.59	0.5	0.56
9	0.76	0.73	0.69	0.8	0.77	0.86	0.83	0.54		0.91	0.8	0.91	0.84	0.92	0.8	0.91	0.8	0.82	0.87	0.73	0.89	0.89	0.89
10	0.79	0.84	0.78	0.88	0.84	0.88	0.82	0.66	0.91		0.81	0.88	0.9	0.9	0.87	0.96	0.8	0.89	0.89	0.82	0.9	0.91	0.9
11	0.6	0.63	0.58	0.71	0.65	0.71	0.78	0.49	0.8	0.81		0.77	0.72	0.79	0.66	0.76	0.67	0.85	0.72	0.62	0.78	0.8	0.78
12	0.81	0.74	0.66	0.77	0.77	0.8	0.8	0.57	0.91	0.88	0.77		0.82	0.83	0.77	0.87	0.82	0.78	0.87	0.74	0.83	0.81	0.86
13	0.73	0.74	0.7	0.85	0.72	0.84	0.81	0.58	0.84	0.9	0.72	0.82		0.78	0.93	0.92	0.73	0.78	0.85	0.79	0.84	0.85	0.79
14	0.69	0.76	0.68	0.76	0.85	0.84	0.79	0.52	0.92	0.9	0.79	0.83	0.78		0.73	0.88	0.75	0.83	0.81	0.67	0.86	0.88	0.87
15	0.69	0.72	0.66	0.83	0.67	0.8	0.71	0.55	0.8	0.87	0.66	0.77	0.93	0.73		0.91	0.68	0.77	0.82	0.76	0.83	0.85	0.74
16	0.77	0.84	0.74	0.85	0.84	0.86	0.8	0.62	0.91	0.96	0.76	0.87	0.92	0.88	0.91		0.79	0.87	0.89	0.81	0.9	0.9	0.84
17	0.7	0.87	0.6	0.7	0.72	0.76	0.73	0.83	0.8	0.8	0.67	0.82	0.73	0.75	0.68	0.79		0.74	0.8	0.89	0.76	0.7	0.79
18	0.66	0.85	0.69	0.75	0.82	0.77	0.7	0.61	0.82	0.89	0.85	0.78	0.78	0.83	0.77	0.87	0.74		0.78	0.74	0.83	0.8	0.79
19	0.76	0.75	0.68	0.82	0.76	0.88	0.8	0.59	0.87	0.89	0.72	0.87	0.85	0.81	0.82	0.89	0.8	0.78		0.76	0.82	0.83	0.83
20	0.66	0.87	0.67	0.73	0.68	0.76	0.67	0.84	0.73	0.82	0.62	0.74	0.79	0.67	0.76	0.81	0.89	0.74	0.76		0.74	0.68	0.73
21	0.69	0.77	0.64	0.79	0.72	0.84	0.77	0.59	0.89	0.9	0.78	0.83	0.84	0.86	0.83	0.9	0.76	0.83	0.82	0.74		0.9	0.86
22	0.68	0.69	0.67	0.83	0.71	0.83	0.76	0.5	0.89	0.91	0.8	0.81	0.85	0.88	0.85	0.9	0.7	0.8	0.83	0.68	0.9		0.84
23	0.78	0.72	0.65	0.77	0.76	0.8	0.78	0.56	0.89	0.9	0.78	0.86	0.79	0.87	0.74	0.84	0.79	0.79	0.83	0.73	0.86	0.84	